



I/ITSEC 2025

NTSA



CMSP 3.0

CMSP Levels: From Youngling to Jedi Master

Professional Development Workshop

4 December 2025

(2 November 2025 Version 2)

Ivar Oswalt, PhD CMSP
The MIL Corporation





➤ Jedi Levels

- Initiate
- Youngling
- Padawan
- Knight
- Master
- Master of the Order
- Grand Master

**Today's
Focus**

➤ M&S Levels

- (CMSS (Student) - *TBD*)
- CMSI (Intern) - NCS Certification
- CMSA (Apprentice) - 1
- CMSA (Apprentice) - 2
- CMSP (Professional) - Practitioner
- CMSP (Professional) - Master
- (CMSP (Professional) - Expert - *TBD*)



- CMSP is the only comprehensive M&S professional certification
- It provides differentiation, community awareness, specialized networks, and membership benefits
- Its Reinvention started at I/ITSEC 2021 with the launch of CMSP 3.0
- Improvements streamline the application process, provide new levels, include updates to the examination, and the creation a vibrant community of practice
- *All M&S practitioners seeking to enhance their credentials and to add a level of distinction to their qualifications - from Intern, Apprentice (I and II), Practitioner, and Master Levels - will find this PDW informative and valuable*



- Learning Objectives
- Introductions
 - Acknowledgements
- Role of M&S, Certification, CMSP
- CMSP
 - Certification Levels
 - Education and Experience
 - Exam Philosophy and Overview
 - Exam Specifics
 - Tracks and Topics / Subtopics
 - Tips, Techniques, and Timeline
- Overview of Topics / Subtopics
 - M&S Types, Applications,...
- Summary of Types of M&S
 - The Type is Right Game 
- Certification Exam
 - Sample Questions
- Review
 - Topics
 - Rapid Fire Game 
- CMSP
 - Context
 - Current Events
- Summary of Key Terms and Concepts
 - Crossword Puzzle Game 
- Course Evaluations



- After this PDW, Attendees will be able to:
 - Describe CMSP's Motivation / Origin and Development
 - Articulate the Ways CMSP Can Benefit their Career Progression
 - Recount the Process for Becoming a CMSP
 - Define CMSP Levels and Types of Questions to be Asked on the Exam
 - Characterize Key Features and Functions of M&S and Supporting Processes
 - Demonstrate, via Gaming Simulations, Knowledge of Relevant M&S Knowledge

That is, Successfully Apply, Pass the Appropriate Exam, and Become a CMSP of the Type that Matches Your Qualifications and Experience

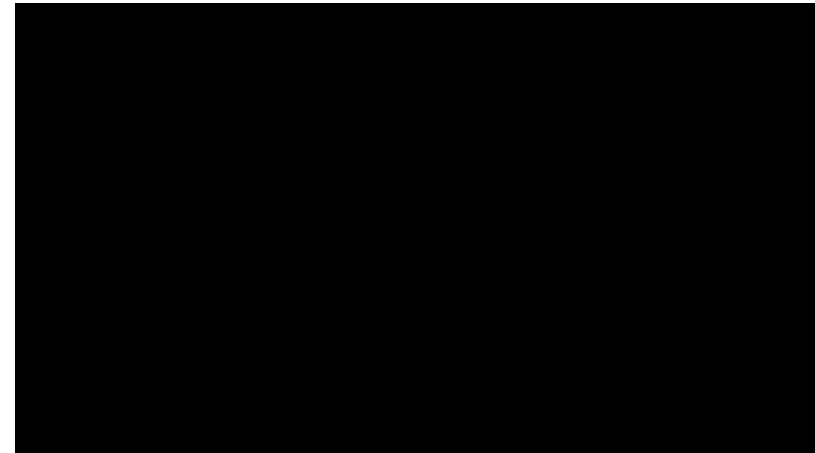


➤ **Ivar Oswalt**

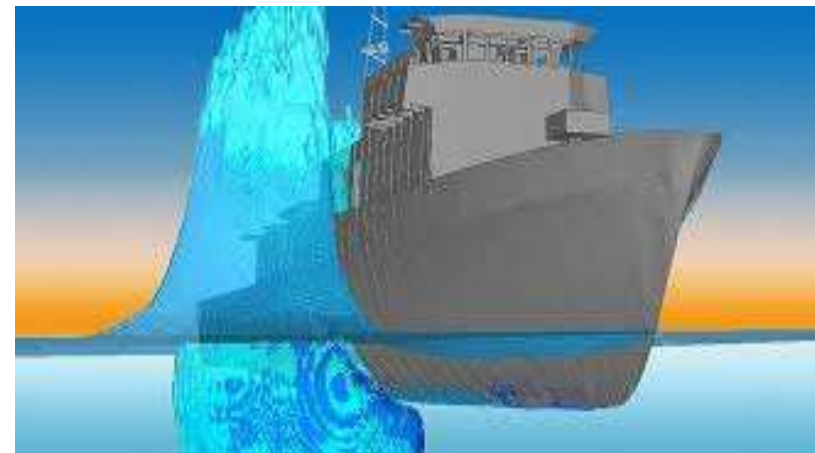
- 30+ Years of M&S experience, supporting the Navy's M&S Office, DoD M&S Office, NRL, etc.
- PhD in 1989, CMSP in 2019, NET+ in 2022
- *Simulation-Based Trainings Incorporation of ML*, MODSIM Best Paper and I/ITSEC BFATG 2019
- *Operationalizing AI in Simulation Based Training*, I/ITSEC 2021
- The Modeling and Simulation Profession, John Wiley & Sons, 2017 - Chapter Contributor, e.g., Observations on ROI
- *Calculating ROI for U.S. DoD M&S*, Hirsch Prize Recipient, ARJ, 2011
- Currently: DON M&S and VV&A Management SECNAVINST, NMSO PP&S, NRL VV&A Support

➤ **Quickly Around the Room**

➤ I'm Motivated To Go From...



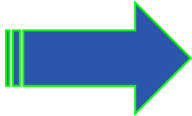
➤ To...





- Dr. Mikel Petty, University of Alabama in Huntsville
- Dr. Amy Henninger, Branch Chief Advanced Computing, DHS
- Mr. Bill Waite, President, The AEgis Corporation
- Mr. William V. Tucker, Boeing
- Ms. Margaret Callahan, The MIL Corporation
- Mr. Daryl Wynn, NSWCC DD DNA



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- Provides assessment without operating or destroying expensive items
- Creates immersive training environments that are otherwise impossible
- Enables the analysis of extremely complex multi-variate problems
- Forecasts the future state of incredibly complex processes
- Allows the controlled examination of items within secure multi-spectral environments
- Increasingly, M&S learns!

“Science used to be composed of two endeavors, theory and experiment. Now it has a third component: **computer simulation**, which links the other two.”
[Colwell, 1999] [Colwell, 2000]



Rita R. Colwell, Ph.D.
Director, NSF
1998-2004



- Certification is the formal confirmation of particular characteristics of a person or organization and is normally provided by an external review, education, assessment, or audit
- Examples Include: Certified Public Accountant (CPA), Professional Engineer (PE), Project Management Professional (PMP), and Network+ (NET+) IT Professional
- Professional Rationale: Certification helps to establish the legitimacy of any occupational field and to standardize the quality of its membership
- Organizational Rationale: Certification helps to demonstrate the qualifications / discriminators of an entity (Corporation, Research Center, etc.)
- Personal Rationale: Certification demonstrates an individual's commitment to superior professionalism, upholding industry standards, and continued learning



- Is a sign of distinction and is increasingly formally recognized
 - Within the M&S community, Commercial and Defense Organizations

- Provides a standard of qualification
 - Enables providers (e.g., potential employees) and consumers (e.g., companies) to communicate

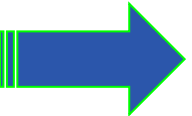
- Increasingly delivers a supportive and career enhancing community
 - CMSP Quarterly Newsletter, Mentorship Program, Local and Regional Events, Scholarship

- Communicates an indicator of currency
 - Publications, presentations, CEUs required for renewal



- **Performance Work Statement: Maneuver Battle Lab Comprehensive Support 2024**
- **10.1 Specialized Education, Certifications, and Credentials.** Experimentation is a specialized skill with far reaching impacts upon Soldiers, Maneuver Formations, and Soldier and Small Unit Modernization. As such it requires unique training and credentials that reduce risk to the Army and its missions. Those risk reduction credentials with required timelines are as indicated below.
- **10.1.1 Certified Modeling and Simulation Professionals. *On day 1 of the contract award, contractor must ensure that the Modeling and Simulation (M&S) Team Manager and at least 50% of all personnel assigned in the Modeling & Simulation Team are Certified Modeling & Simulation Professionals (CMSP); vendor must ensure 100% M&S personnel must obtain CMSP within the first 60 days upon award.***



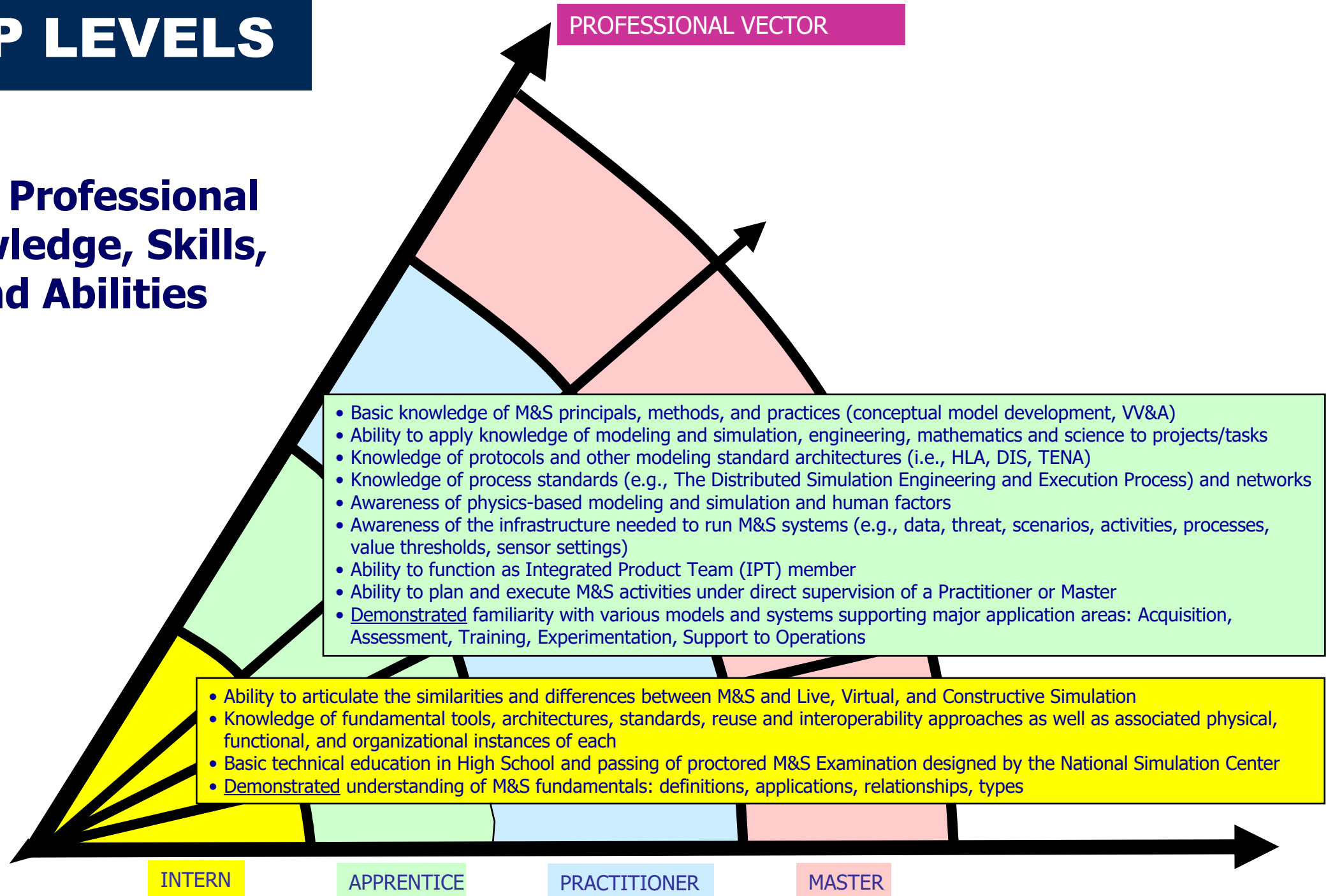
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- The CMSP is a professional certification, governed by NTSA and awarded by the NTSA President and a Senior M&S SME Board
- It designates individuals who have attained knowledge and experience in M&S – ***the extent to which varies by level***
- Requirements for certification are:
 - Evidence of sufficient M&S education and experience
 - Supporting references forwarded from professional colleagues
 - Passing an examination
 - Signing a statement of ethics
 - Paying application fee
- CMSP is good for 4 years, after which recertification is required
 - Continuing education, papers, presentations, etc.
 - Paying a fee

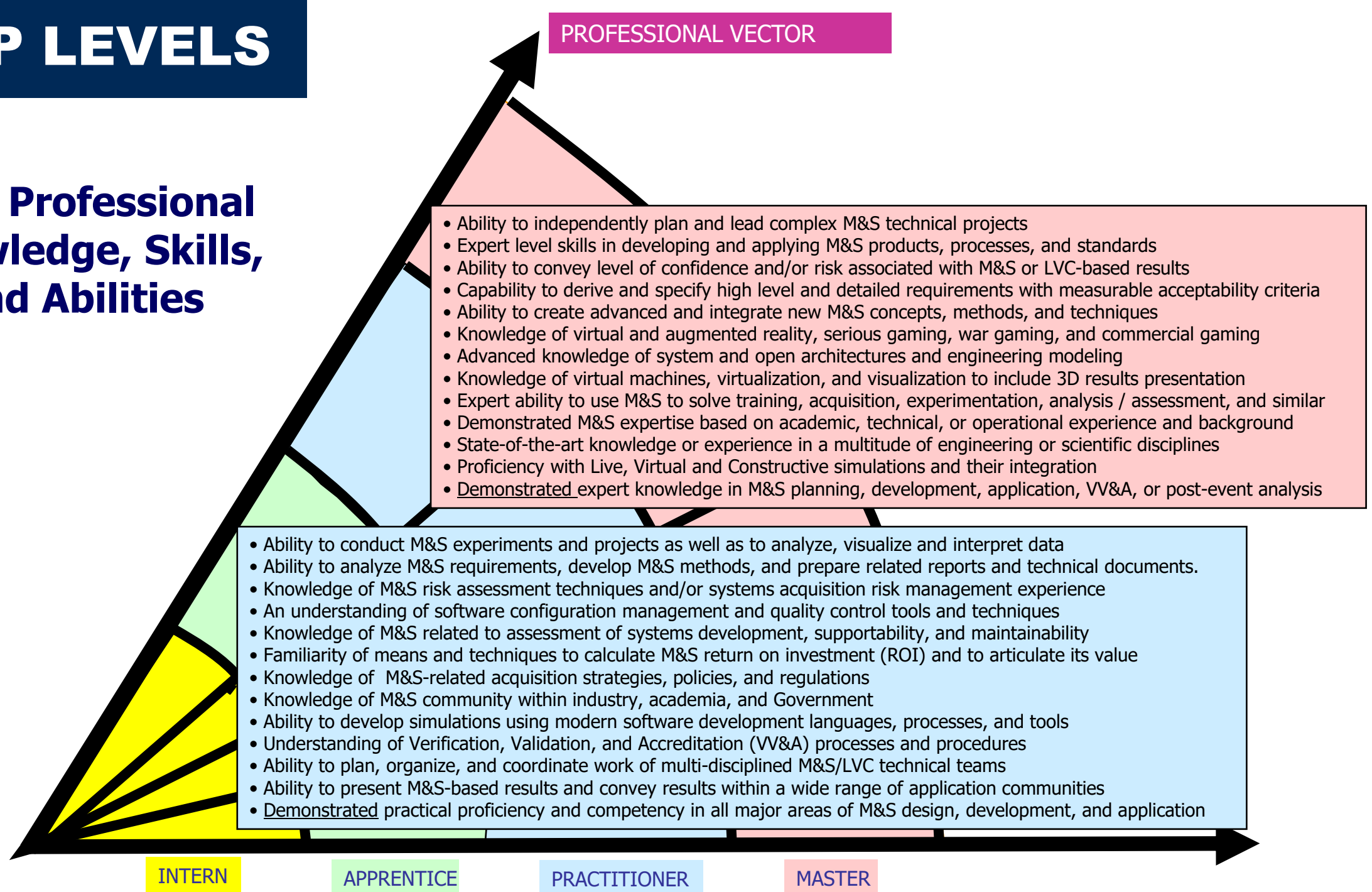
CMSP LEVELS

M&S Professional Knowledge, Skills, and Abilities



CMSP LEVELS

M&S Professional Knowledge, Skills, and Abilities





- This level is designed for individuals who have just graduated and are very new to the M&S field and serves as a foundation for future advancement
- Identifies the ability to articulate the similarities and differences between M&S and Live, Virtual, and Constructive Simulation
- Knowledge of fundamental tools, architectures, standards, reuse and interoperability approaches as well as associated physical, functional, and organizational instances of each
- Technical education in M&S and the passing of proctored M&S Examination designed by the National Simulation Center
- Demonstrated understanding of M&S fundamentals: definitions, applications, relationships, and types



- This level is designed for individuals who are entering the M&S field and serves as a foundation for future advancement
- Identifies individuals who have overall an awareness of M&S concepts, methods, and applications
- Individuals possess an entry-level understanding of M&S principles and practices and are committed to expanding their knowledge and understanding of the M&S discipline
- Demonstrated familiarity with various models and systems supporting major application areas: Acquisition, Assessment, Training, Experimentation, etc.



- This level designates professionals who possess applied knowledge of M&S principles and practices in a variety of domains
- They understand M&S applications and their role in addressing current and future challenges in specific contexts
- Designed for M&S professionals who have a demonstrated ability to lead technical teams, conduct short-term studies, translate project requirements into model contexts, and coordinate with SMEs and key stakeholders
- Ability to develop basic models and simulations using modern software development languages
- Demonstrated practical proficiency and competency in all major areas of M&S design, development, and application



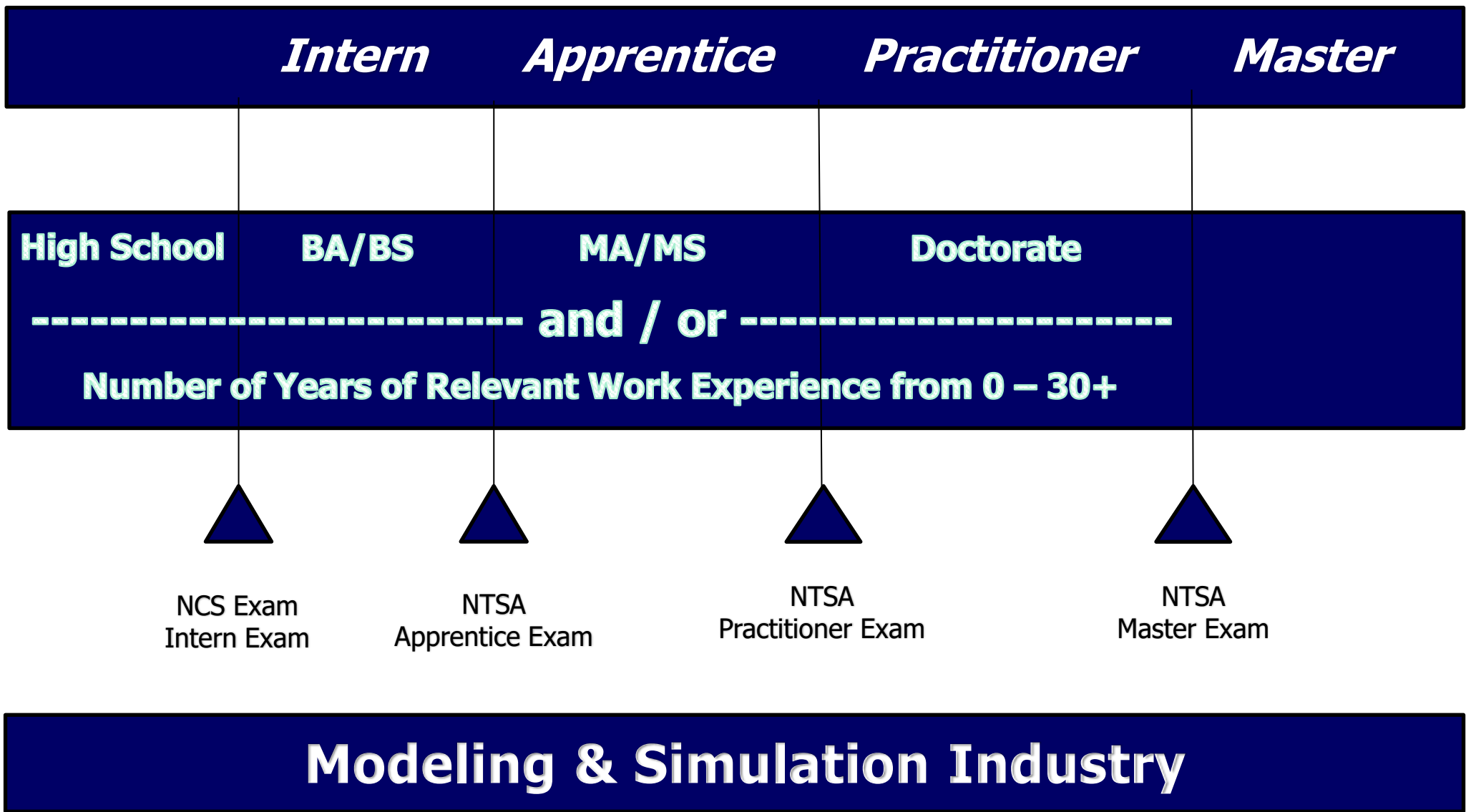
- This level designates professionals who have a demonstrated understanding of the M&S BoK its application in a variety of contexts
- Possess the capability to plan and execute short- and long-term M&S projects, design and implement complex and sophisticated models, conduct advanced research, communicate findings, and expand the application of M&S into new domains
- Ability to independently plan and lead complex M&S technical projects, to derive and specify high level and detailed requirements with measurable acceptability criteria, etc.
- Demonstrated ability to present M&S designs, implementation architectures, and results to other M&S professionals and to senior leaders



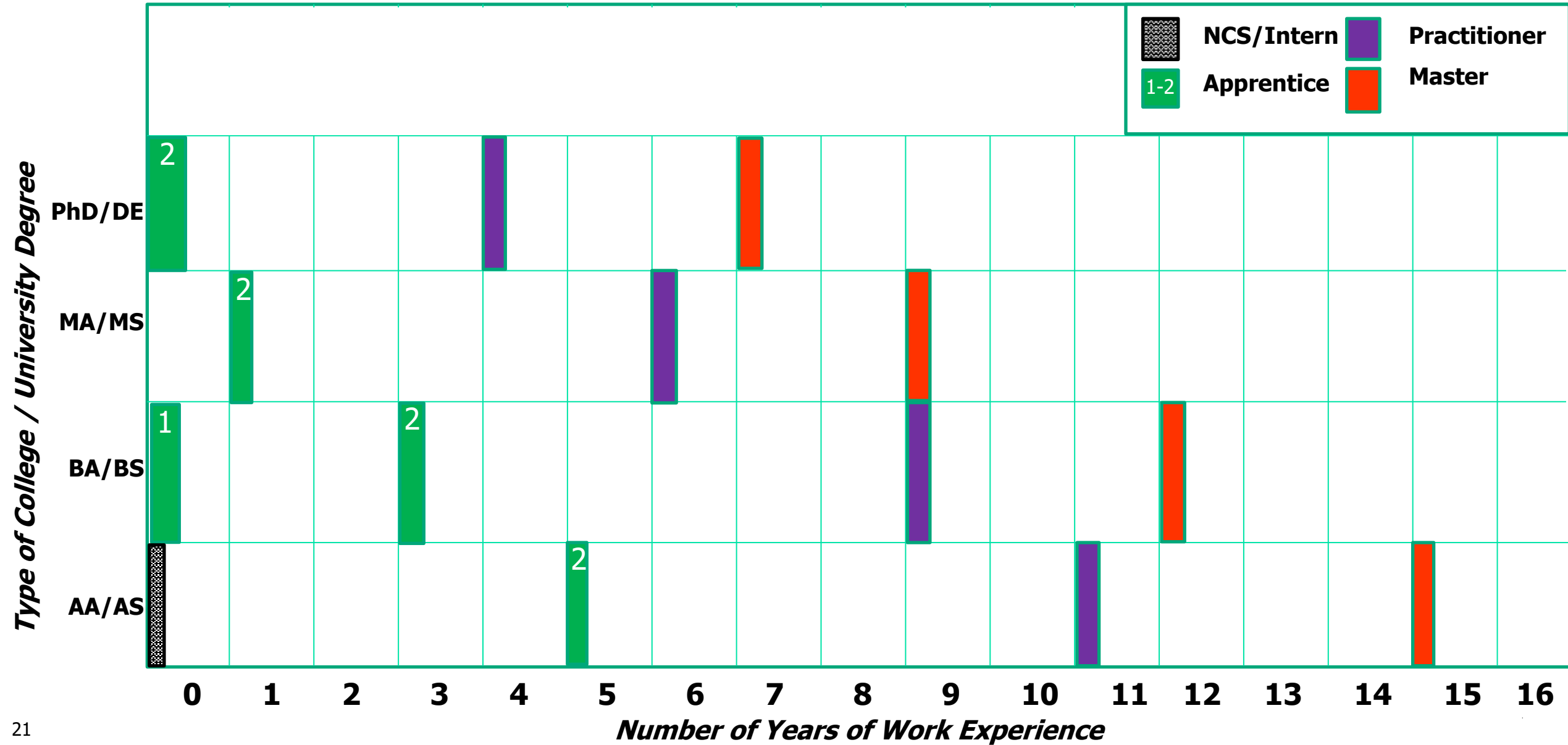
CMSP
Designation

Education
And Experience

Certification
Exam Level



EDUCATION AND EXPERIENCE QUALIFICATIONS TO TAKE AN EXAM





- Ensure that successful candidates have an appropriate and *representative understanding of the full spectrum of M&S*
- Designed to be a challenging trial to garner respect and credibility and to demonstrate professionalism
- Degree of exam difficulty is targeted to level of certification being sought – Intern, Apprentice, Practitioner, or Master - currently in a take-home format
- Study is required to successfully complete the examination
- But part of the intent, especially for Practitioner and Master, is that applicants will research and learn new M&S knowledge by Taking the Exam



- Scope is defined by a consensus-based M&S Body of Knowledge (BoK)
- Composed of questions drawn from all BoK topics and subtopics
- Every question is traceable to a published, publicly-available, and peer-reviewed source
- Each candidate is provided an automatically generated exam instance consisting of questions selected from the question bank
- The exam's design is customized by level
- An on-line learning management system allows candidates to take the exam conveniently
- Each exam type requires a 70% score to pass (skipped questions are scored as incorrect)



➤ Intern

- Proctored exam of 50 questions in 55 minutes
- National Simulation Center's Certification / Cross Certified with NTSA's CMSP
- Cost is \$195.00

➤ Apprentice

- Exam consists of 40 questions in 4 hours
- Cost is \$150.00

70% +

➤ Practitioner

- Exam consists of 2 sets of 40 questions. 4 hours for the 1st set. 6 hours for the 2nd set.
- Both sets must be completed within 7 days.
- Cost is \$275.00

➤ Master

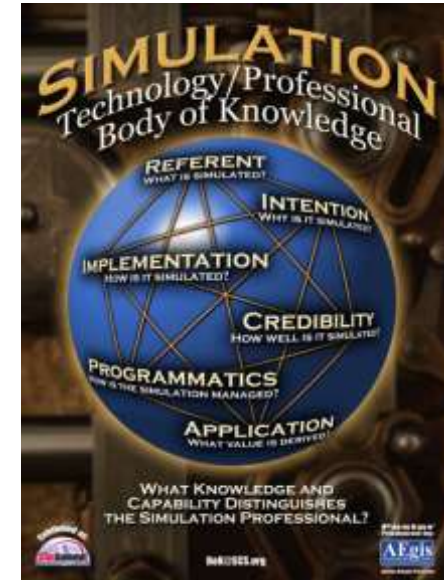
- Exam consists of 3 sets of 40 questions. 4 hours for the 1st set. 6 hours for the 2nd set.
- 8 hours for the 3rd set. All must be completed within 14 days.
- Cost is \$400.00



- We recommend that you review the resources listed below as a study tool for the exam. In addition, you can review the slides from this CMSP PDW
 - Modeling and Simulation Fundamentals: Theoretical Underpinnings and Practical Domains
 - Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice
 - The Profession of M&S: Discipline, Ethics, Education, Vocation, Societies, and Economics
 - Principles of Modeling and Simulation: A Multidisciplinary Approach
- These monograms can be borrowed from NTSA to help review for the exam
 - You may borrow the books requested for 1 month and will have to only pay for shipping
- The exam platform also includes practice quizzes that you can take to get a good sense of each exam part.



- Intent
 - Include topics spanning the M&S Body of Knowledge
- Structure
 - 8 topics, 54 subtopics
- Content:
 - Initially based on SimSummit M&S Body of Knowledge Index
 - Revised per expert recommendations
 - Revised per source availability and topic testability





1. Concepts and context

- 1.1 Fundamental terms and concepts
- 1.2 Categories and paradigms
- 1.3 History of M&S

2. Applications

- 2.1 Training
- 2.2 Analysis
- 2.3 Experimentation
- 2.4 Acquisition
- 2.5 Engineering
- 2.6 Test and evaluation

3. Domains / Question Context

- 3.1 Combat and military
- 3.2 Aerospace
- 3.3 Medicine and health care
- 3.4 Manufacturing and material handling
- 3.5 Logistics and supply chain
- 3.6 Transportation
- 3.7 Computer and communications systems
- 3.8 Environment and ecology
- 3.9 Business
- 3.10 Social science
- 3.11 Energy
- 3.12 Other domains of use

4. Modeling Methods

- 4.1 Stochastic modeling
- 4.2 Physics-based modeling
- 4.3 Structural modeling
- 4.4 Finite element modeling and CFDs
- 4.5 Monte Carlo simulation
- 4.6 Discrete event simulation
- 4.7 Continuous simulation
- 4.8 Human behavior modeling
- 4.9 Multi-resolution simulation
- 4.10 Other modeling methods

5. Implementation

- 5.1 Modeling and simulation life-cycle
- 5.2 Modeling and simulation standards
- 5.3 Development processes
- 5.4 Conceptual modeling
- 5.5 Specialized modeling and simulation languages
- 5.6 Verification, validation, and accreditation
- 5.7 Distributed simulation and interoperability
- 5.8 Virtual environments and virtual reality
- 5.9 Human-computer interaction
- 5.10 Semi-automated forces/computer generated forces
- 5.11 Stimulation

6. Supporting tools, techniques, and resources

- 6.1 Major simulation infrastructures
- 6.2 M&S resource repositories
- 6.3 M&S organizations

7. Business and management of M&S

- 7.1 Ethics and principles for M&S practitioners
- 7.2 Management of M&S projects and processes
- 7.3 M&S workforce development
- 7.4 M&S business practice and economics
- 7.5 M&S industrial development

8. Related communities of practice and disciplines

- 8.1 Statistics and probability
- 8.2 Mathematics
- 8.3 Software engineering and development
- 8.4 Systems science and engineering



- Complete pre-requisites: Application, References, Etc.
- Pick Level { *Consider your strengths and limitations...*
- Pick Start Time { *Consider your time commitments, etc.!*
- Gather Up Source Material
- Start

My Suggestions...

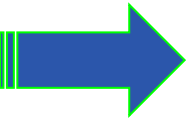
- Skim
- Segregate
 - Easy, Medium
 - Hard, Super Hard
- Answer
 - Normal Question Strategies Apply
- Submit

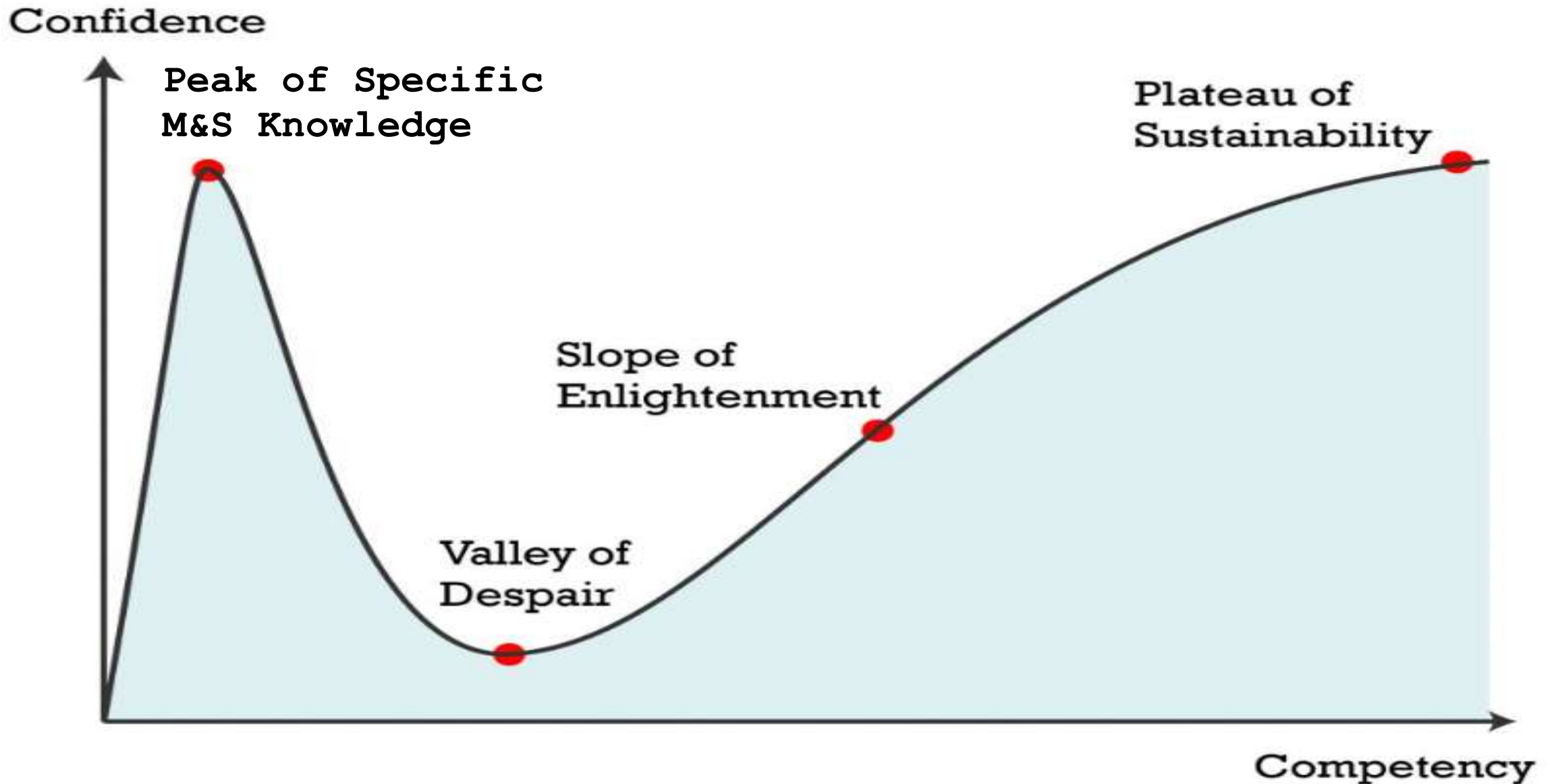
- Finish

- Read the entire question
- Answer questions you know first
- Eliminate wrong answers
- Look for words from the question in the answers
- Select the best answer
- Read every answer option
- Make an educated guess



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- Typically, M&S is performed to generate data to support a decision maker or an activity
- M&S can be used to provide data to support studies to:
 - **Describe** how systems could, would, or do operate
 - **Predict** how much a system will cost, or how many units will be required, or the effects of a change
 - **Predict** the effect of changes to the system
 - **Prescribe** best approach to a problem or condition
- Why not use the real system?
 - Not yet available
 - Too dangerous or expensive to use
 - **Live tests can be destructive**
 - Need to simulate system under unusual or undesirable environmental conditions
 - Need to analyze randomness in a system
 - Impossible to observe internal processes





- Essential terminology, foundational concepts, community consensus categorizations, and overarching modeling paradigms; history of the development and use of M&S.

1. Concepts and context

- 1.1 Fundamental concepts and terms

- 1.2 Categories and paradigms

- 1.3 History of M&S





The real system



The model we should've built



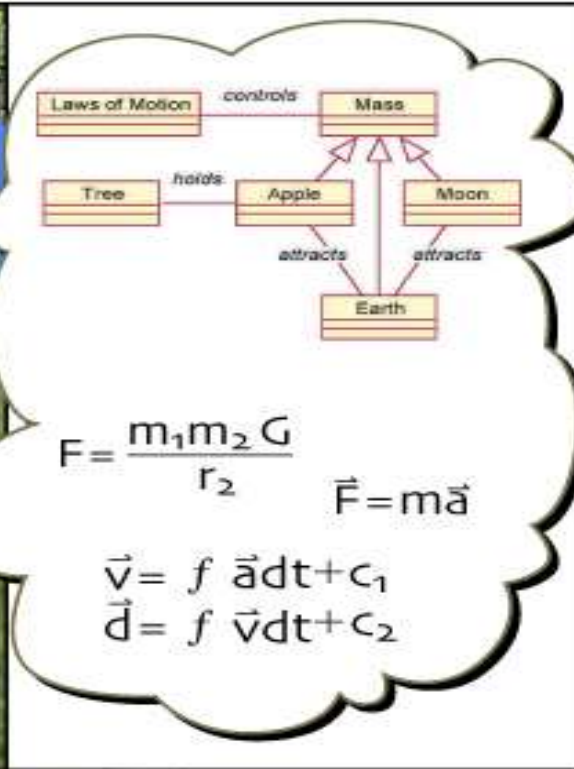
The model we tried to build



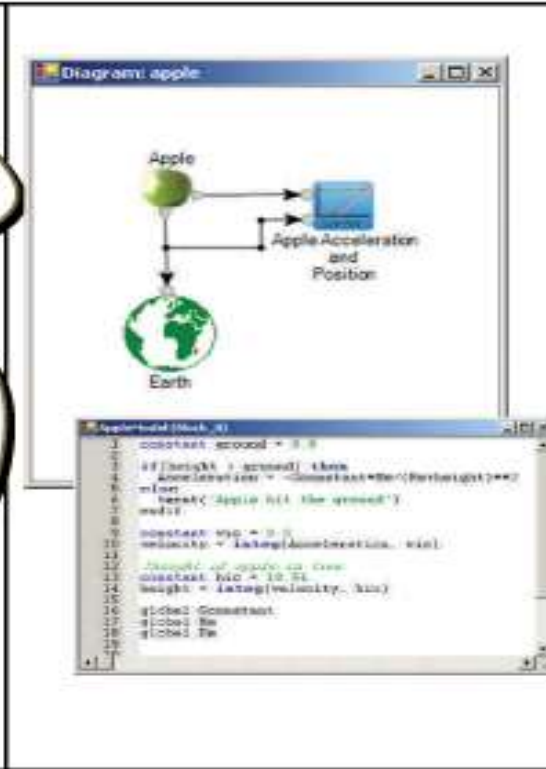
The model we actually built



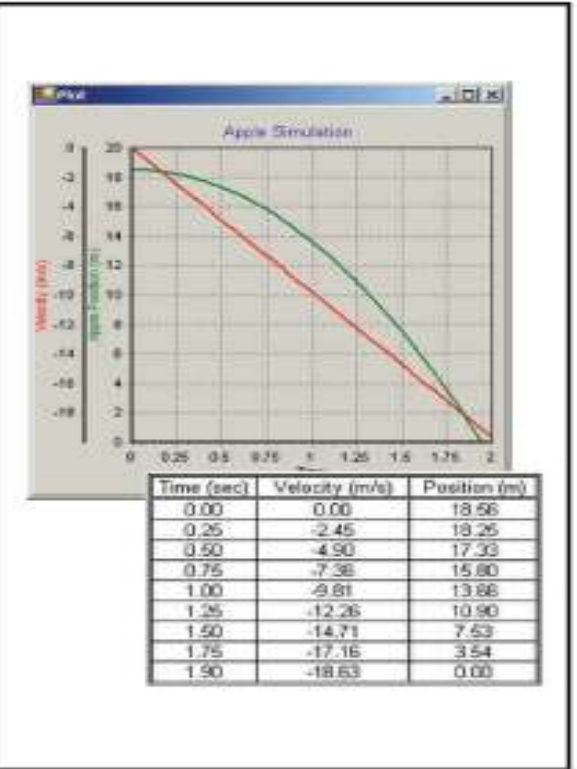
Real World



Conceptual Model



Simulation



Analytical Results

➤ *How would you define each step?*



- **Model:** A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process
- **Conceptual Model:** An implementation neutral (simplified) representation of a system that provides a bridge between the developer and the user
- **Simulation:** A method for implementing a model over time / an imitation of a situation or process
- **Game:** A competition between human adversaries, based on rules, for entertainment or learning
- **M&S Includes:** Emulators, prototypes, simulators, stimulators, appended trainers, etc.
- **Monte-Carlo Simulations:** Uses (pseudo) random samples of parameters or inputs to explore complex behavior
- **Distributed or Federated Simulations:** Geographically remote simulations acting against each other in an LVC environment
- **Live Simulation:** Real people employing real systems in a non-operational role or location (e.g., on a training range)
- **Virtual Simulation:** Real people operating simulated systems in a synthetic environment
- **Constructive Simulation:** Simulated people operating simulated systems in a simulated environment
- **Parametric:** System-level represented by a set of generic algorithms and data structures
- **Engineering:** Captures component functionality rather than the details of signal processing
- **Emulative:** Sub-component / signal processing level of detail sufficient to support detailed analysis





- **Simuland:** The object, process, system, or phenomenon that is to be simulated. For instance, in mannequin-based patient simulators, the simuland is a human patient
- **Calibrate:** To calibrate a model is to determine reasonable values for critical model parameters
- **Referent:** A codified body of knowledge about a thing being simulated
- E.g., Validation Referent: Is the best or most appropriate codified body of information available that describes characteristics and behavior of the reality represented in the simulation
- **Constraint Model:** Constraint-based modeling is a mathematical approach, in which the outcome of each decision is constrained by a minimum and maximum range of limits
- **Conceptual Model:** Conceptual modeling is the abstraction of a simulation model from the real-world system that is being modeled and describing it in an implementation neutral manner
- **Functional Model:** Is a (graphical) representation of a system. Each building block represents a discrete function. The inputs and outputs flow in and out of the system and between functions.
- **Declarative Model:** Uses symbolic expressions to represent models to formalize high-level mathematical models. They rely on preconfigured capabilities in the language to accomplish a task without explicit case-by-case instructions on what steps to take. Declarative programming focuses on the end result.
- **Agent Based Model:** Agent models are generally top-down, with the model focusing on the overall collective behavior of the set of agents

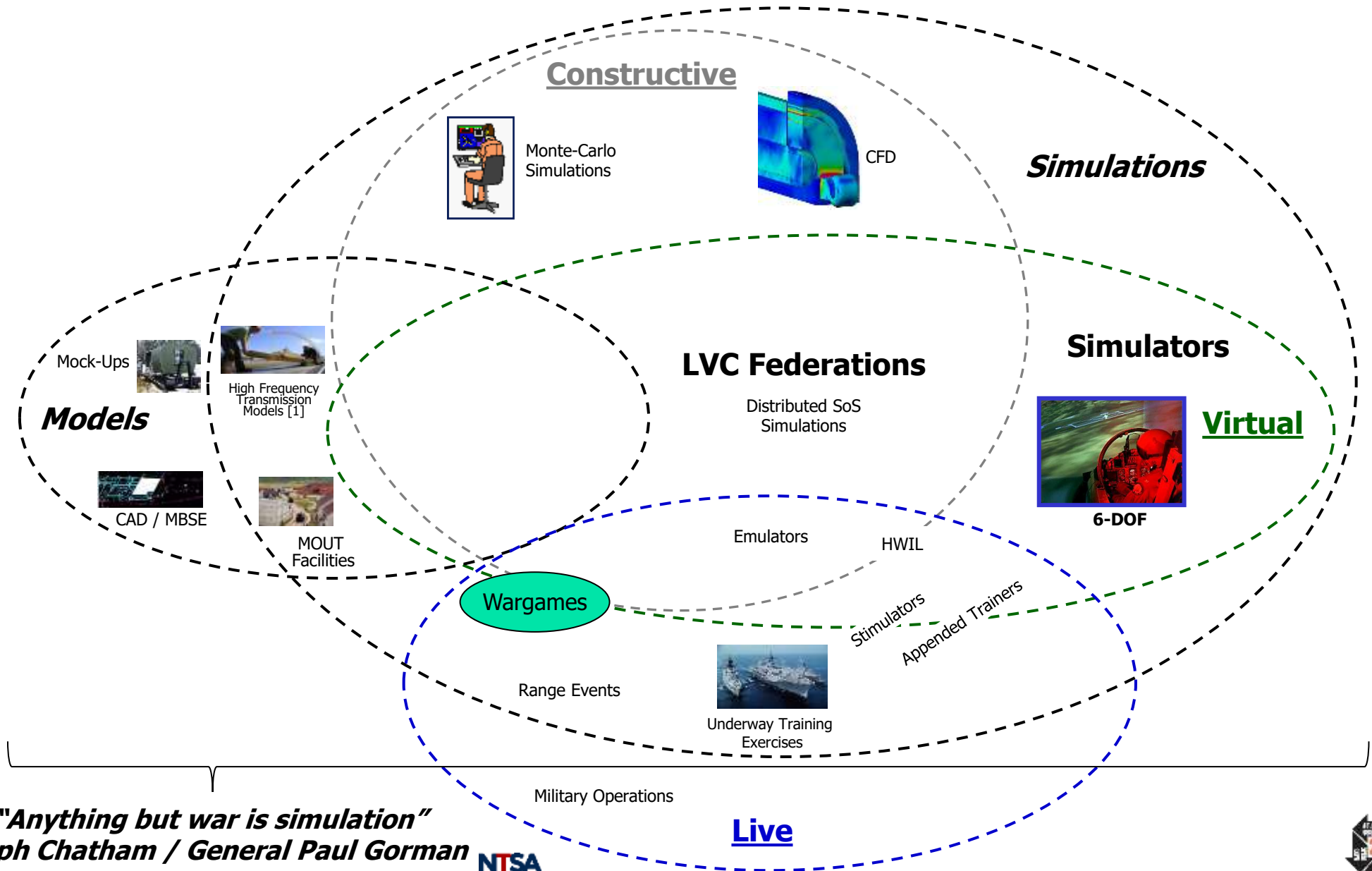




Where do M&S
Systems that you
know fit?

Where do Wargames fit?

- Events with Real People
- Gaming Simulations
- Can use M&S for Adjudication



[1] - S. R. Best, "On the use of scale brass models in HF shipboard communication antenna design," in *IEEE Antennas and Propagation Magazine*, vol. 44, no. 2, pp. 12-23, April 2002.

CAD - Computer Aided Design
CFD - Computational Fluid Dynamics
DOF - Degrees of Freedom,
HWIL - Hardware in the Loop
JSE - Joint Simulation Environment
MOUT - Military Operations on Urban Terrain,
SoS - System of Systems

"Anything but war is simulation"
Ralph Chatham / General Paul Gorman



The 1942 model C-3 Link Trainer was manufactured by Link, an organ and player piano maker. It was used by the allies during World War II to train pilots to fly using only instruments. During World War II, 6271 Link trainers were delivered to the Army and 1045 to the Navy. The Link trainers were also used by 35 foreign countries. Movement of the trainer is accomplished by vacuum operated bellows, controlled by valves connected to the control wheel (or stick) and rudder pedals. An instructor sat at the desk and transmitted radio messages which the student in the Link heard through his earphones.



Puppets



Simple 6DOF



Simple PC



Multiple PCs+



PC Cockpit and Visuals



PC Cockpit and 3 Visuals



Emulated Cockpit and Visuals



6DOF and Visuals



Multiple 6DOFs and Visuals+



6DOF, Visuals+, Associates



A/C Plus Other Warfare Areas



Plus Multi-Echelon C2

So:

- What has changed?
- What has NOT?



- Important and cross-cutting M&S application types; modeling methods and organizing principles for each.

2. Applications of M&S

2.1 Training

2.2 Analysis

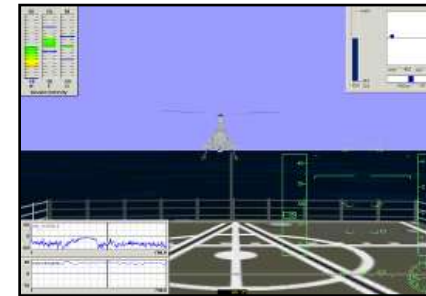
2.3 Experimentation

2.4 Acquisition

2.5 Engineering

2.6 Test and Evaluation

2.7 Wargaming



Digital
Modeling



Hardware
In-The-Loop



Systems Test and
Measurement Facilities



Flight Testing
Open Air Training



M&S used to teach a knowledge, skill, or ability to the trainee / user of the simulation

- Realistic enough to result in training transfer
- ***Much safer***, more forgiving of mistakes
- Especially valuable in teaching skills relative to unusual and/or dangerous situations

The goal is to achieve a defined level of proficiency



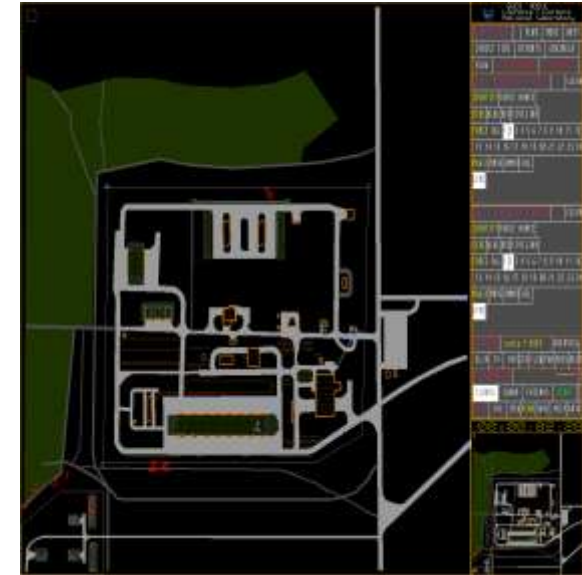


- In October 1992, during a NATO Simulation / Exercise...
- The TCG Muavenet, a Turkish Navy Destroyer was crippled by two Sea Sparrow missiles
- These missiles were launched from the USS Saratoga
- Senior officers on watch on the Saratoga decided to take advantage of the NATO exercise to rehearse the procedures for responding to a simulated attack, according to the Navy investigation
- The American sailors, awakened late at night, mistook a drill for an actual attack
- The result was the killing 5 Turkish sailors and the wounding of 15





- M&S used to define / understand, predict, or assess a real or notional system or idea
- To answer questions
 - That vary from Factory Output, to Transportation Bottlenecks, to Force Structure, ...
- Repeatability often desirable
 - To avoid confounding variability
- Requires careful experimental design
 - Trials are pre-planned to cover the spanning cases
 - Multiple trials for statistical significance

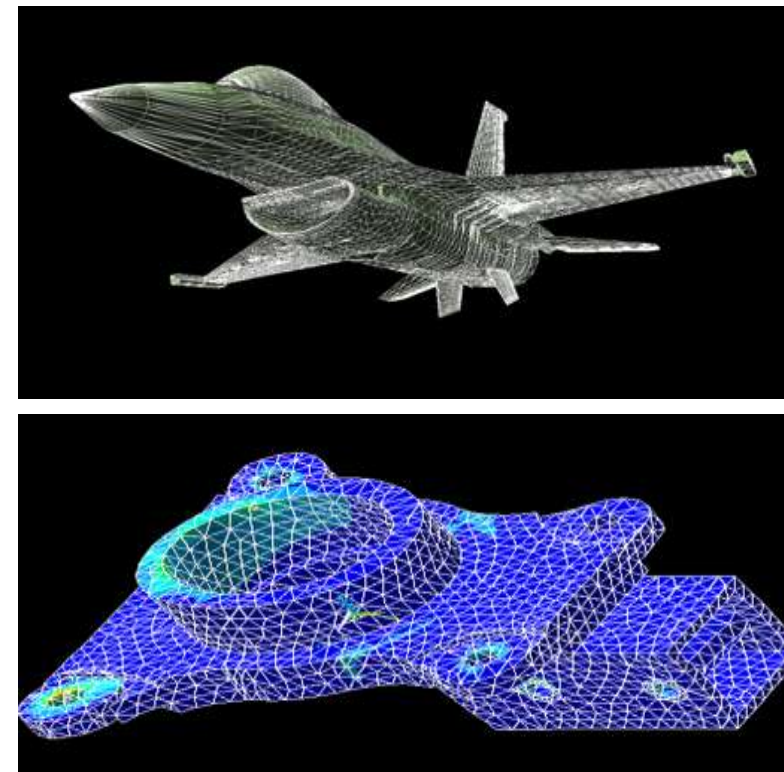


JCATS, Wurtsmith AFB



- M&S used to develop, analyze, or test an engineering design
- Model real and proposed systems and components
- Models are physics-based, no “behavior”
- No virtual environment or simulators
- User not expected to benefit from experience of execution
- Primary goal: Generate engineering insights

FEMs





- M&S can be a source of additional test “data” when actual testing is:
 - Too expensive or impractical to conduct
 - Too dangerous to conduct
 - Prohibited by treaties, laws, or policies
- Result in savings in cost, schedule, and/or number of test articles
- Can provide higher confidence levels due to having more data

- But...
 - Accuracy - M&S cannot fully replicate live T&E
 - Real world outcomes dependent on interactions which are complex and difficult to fully understand, quantify and model
 - M&S can be very expensive to develop, especially for first user
 - M&S is not a replacement for testing - By law, OE & OS cannot be evaluated solely via M&S
 - VV&A can be very expensive and time consuming



A war game is defined by four attributes (RAND 2024):

➤ **Contested**

- Features an intelligent adversary whose interest's conflict with the player's interests.

➤ **In a synthetic environment**

- Scenario based, within an operational area, where terrain, distance, etc. matter
- Some, but not all, employ M&S for adjudication

➤ **Players experience the outcomes of their decisions**

- Players must consider the problem beyond the opening moves

➤ **Requires interdependent decision making**

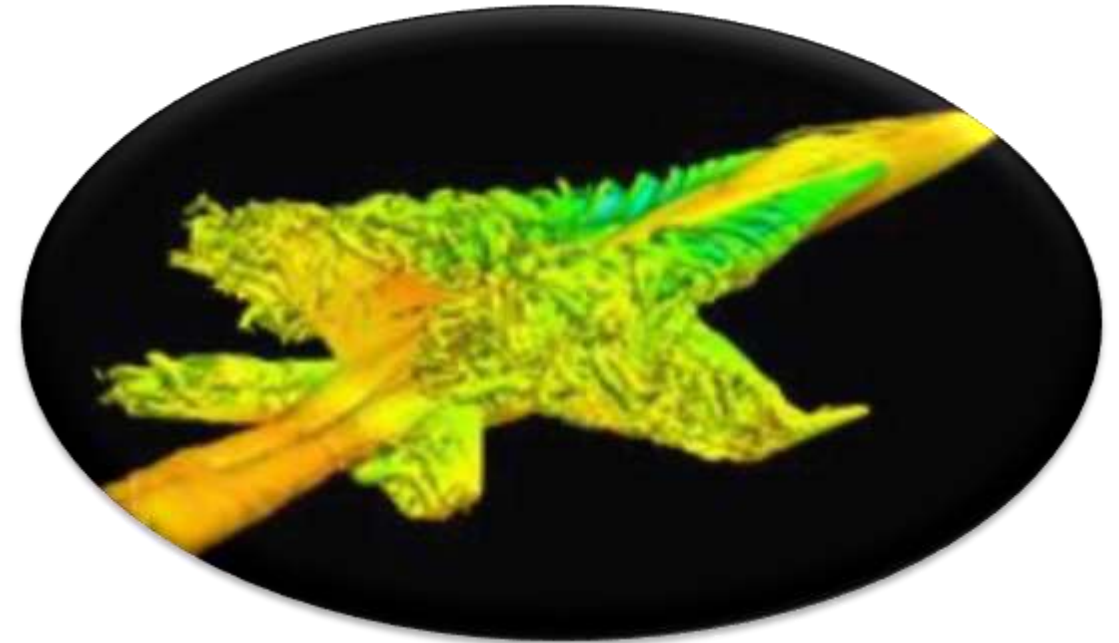
- Intelligent decisionmakers (players) engage in strategic thinking by consciously considering the choices and actions of others.



- Technical aspects of widely used modeling methods; characteristics and suitable applications for each.

- Modeling Methods

- Deterministic
- Stochastic Modeling
- Physics-based Modeling
- Finite Element Modeling and CFD
- Monte Carlo Simulation
- Discrete Event Simulation
- Continuous Simulation
- Human Behavior Modeling
- Multi-resolution Simulation
- Real-time Simulation
- Other Modeling Methods





- Model where a given set of inputs will produce a determined, unique set of outputs
- Example: *Chess*
 - No dice rolls or random elements
 - Same decisions → same results
- Example: Engineering simulation
 - FEM simulation of engine part
 - Physics-based models deterministic
 - Output determined by input





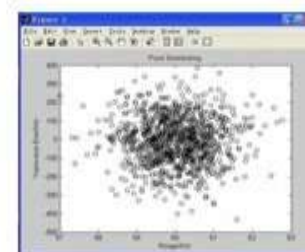
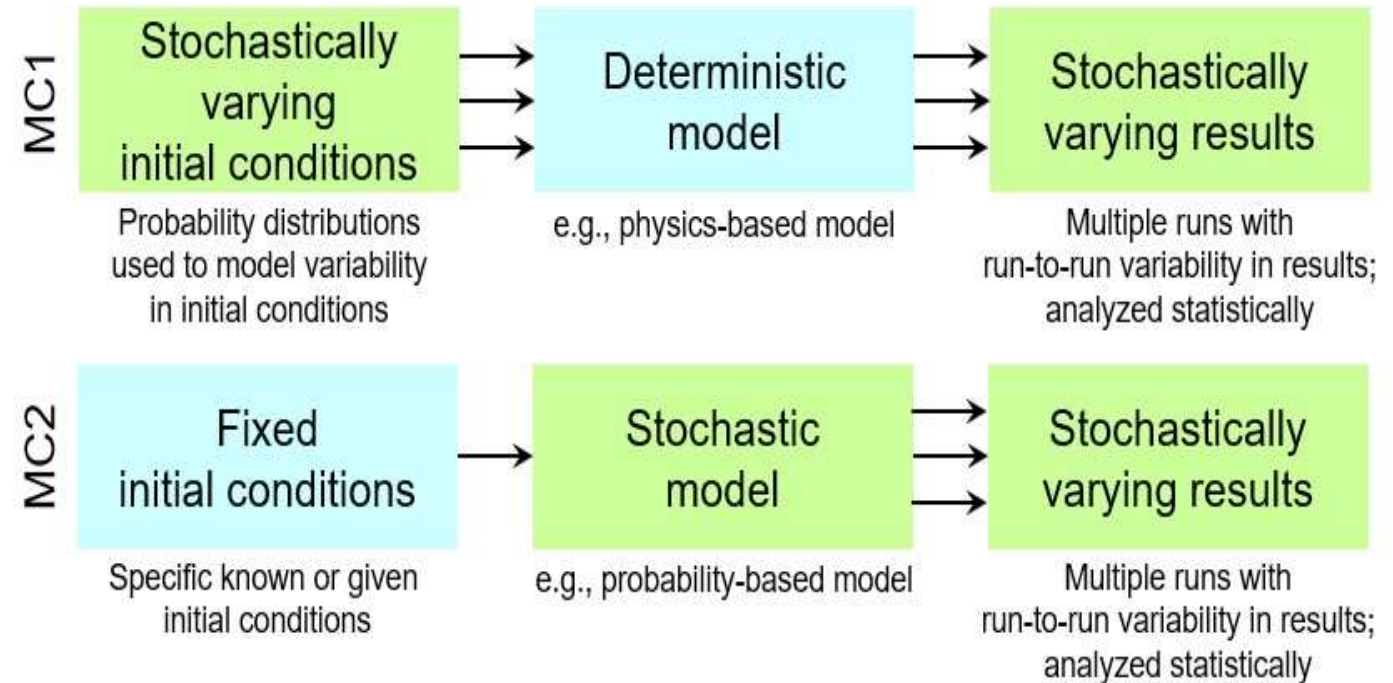
Two Types

Stochastic initial conditions input to deterministic model

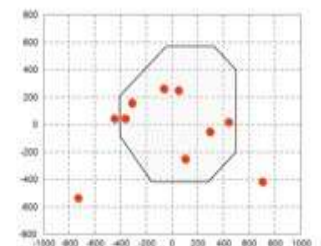
- ❖ Randomly generated initial conditions provided as input, model calculates results deterministically

Deterministic initial conditions input to stochastic model

- ❖ Given input, model calculates results stochastically to generate physics or process outcomes



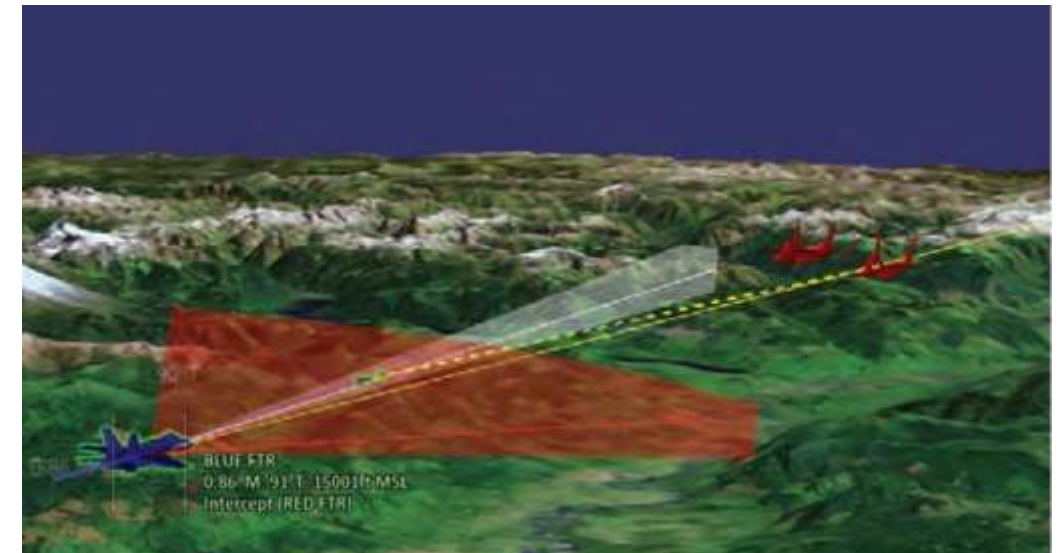
MC1
Missile impacts
[Zhang, 2008]



MC2
Bombing accuracy
[BanksJ, 2010]

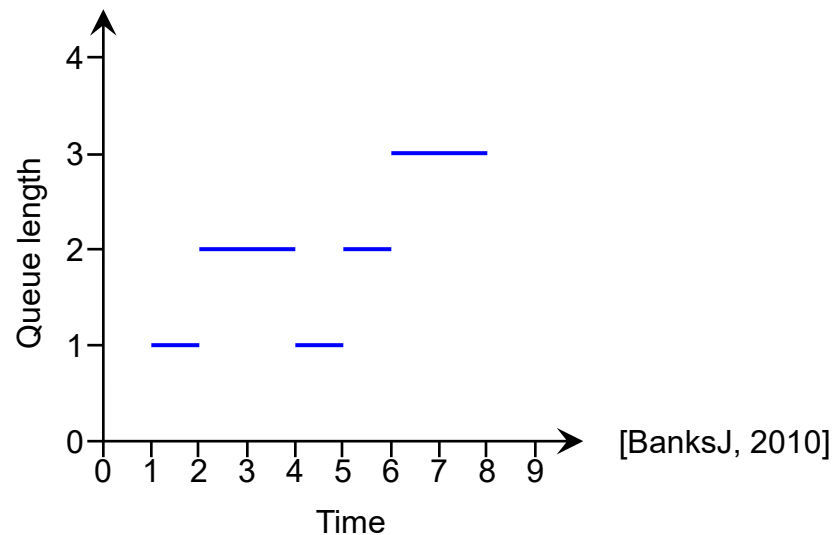


- Simulated people operating simulated systems in a simulated environment
- Real people set up the simulation and often provide run-time inputs
- Varying fidelity depending on analysis, training, or decision support objectives
- Replay can take place faster than real time, at real time, or slower than real time depending on the application
- Visualizations yield greater understanding of scenario development / outcomes





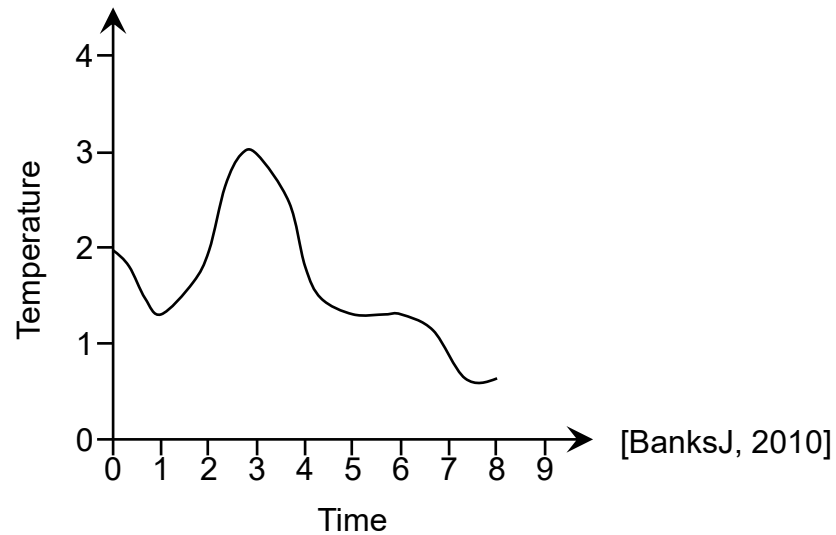
- Model state variables change only at a discrete set of points in time (“events”)
- Simulation using discrete models and event handling / event-driven
- E.g., Aircraft launch → Arrives on station → Starts close-air-support



```
t = 0
while t < end_time
    t = time of next event e
    process event e
    possibly schedule future events
endwhile
```



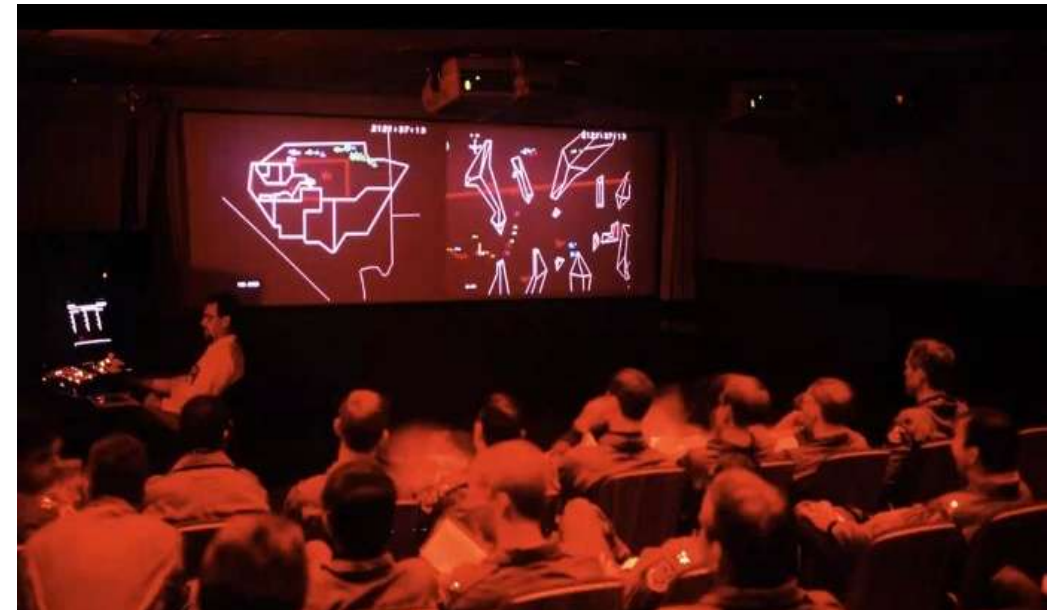

- Model where state variables change (pseudo-) continuously over time. Typically, time advances in small fixed time steps
- AKA “time-stepped” [Banks J, 2010]
- Continuous simulation uses continuous models



```
t = start_time
while t < end_time
    t = t + Δt
    calculate simulation state at t
endwhile
```

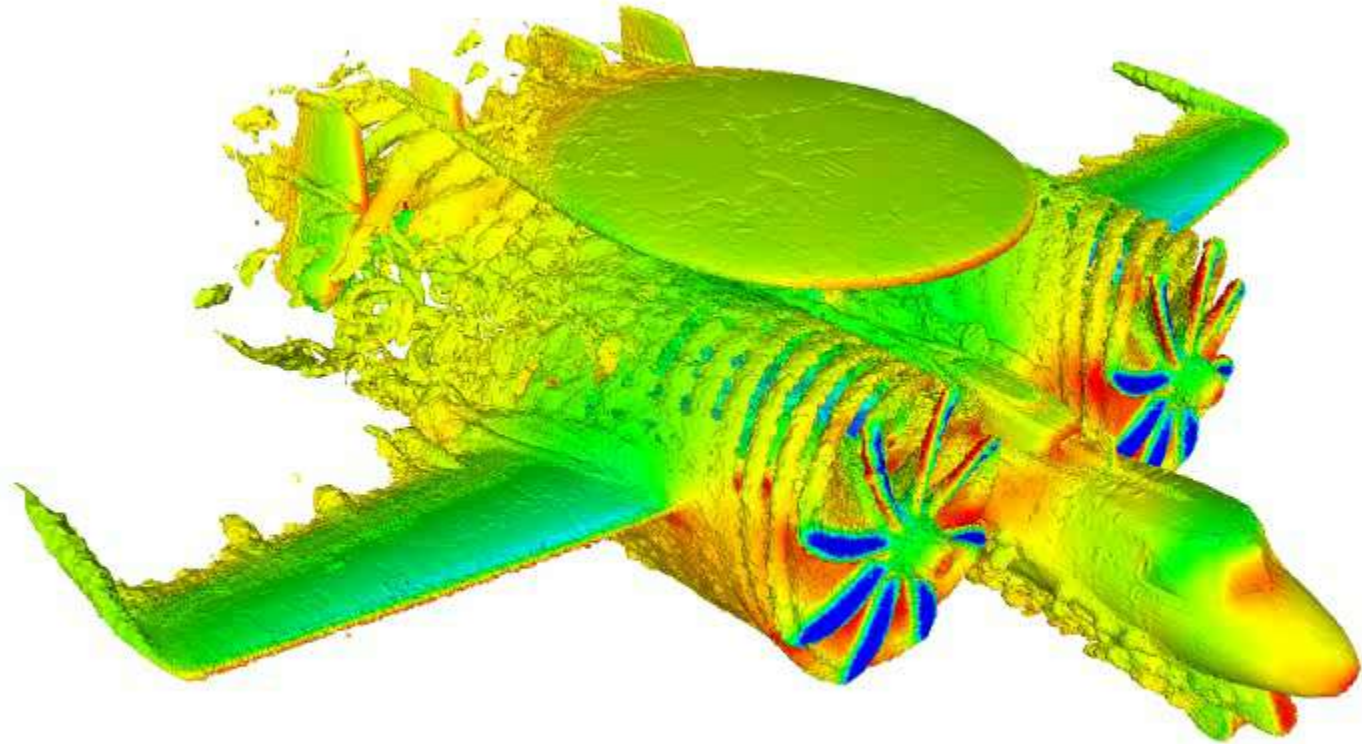


- Real people employing real systems in a non-operational role or location
- The location could be training range or while underway prior to reaching the Force's Area of Responsibility
- The advantage is that this has the operator within their warfighting platform
- Disadvantages include the high cost of conducting the event and the greater risk of platform loss and/or personnel injury



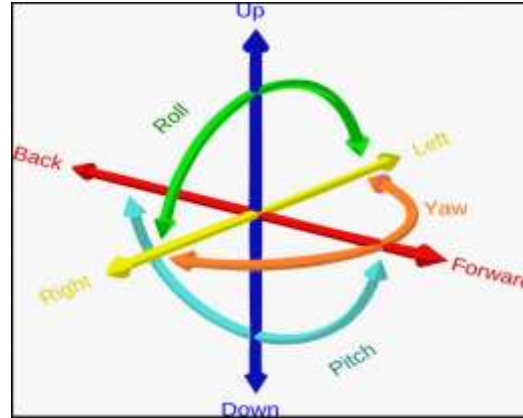


- CFD is the process of mathematically modeling a physical phenomenon involving fluid flow and solving it numerically using high performance computer resources
- The propeller geometry being analyzed / investigated on the right is representation of a modern eight-bladed design for high-speed turboprop aircraft





- Real people operating simulated systems in a synthetic environment
- Appropriate visual resolution and field of view
- Required motion - from none to 6 DOF
- Varying fidelity in vehicle human-machine interface depending on training objectives





➤ Analog



➤ Virtualized Hybrid Simulation Systems (LVC++)

➤ Quantum Simulation

➤ Linking Simulation to the Human Brain $\xrightarrow{*}$

➤ Others...



The Matrix's "digital rain" is one of the most recognizable images from the film. ANIMAL LOGIC/WARNER BROS

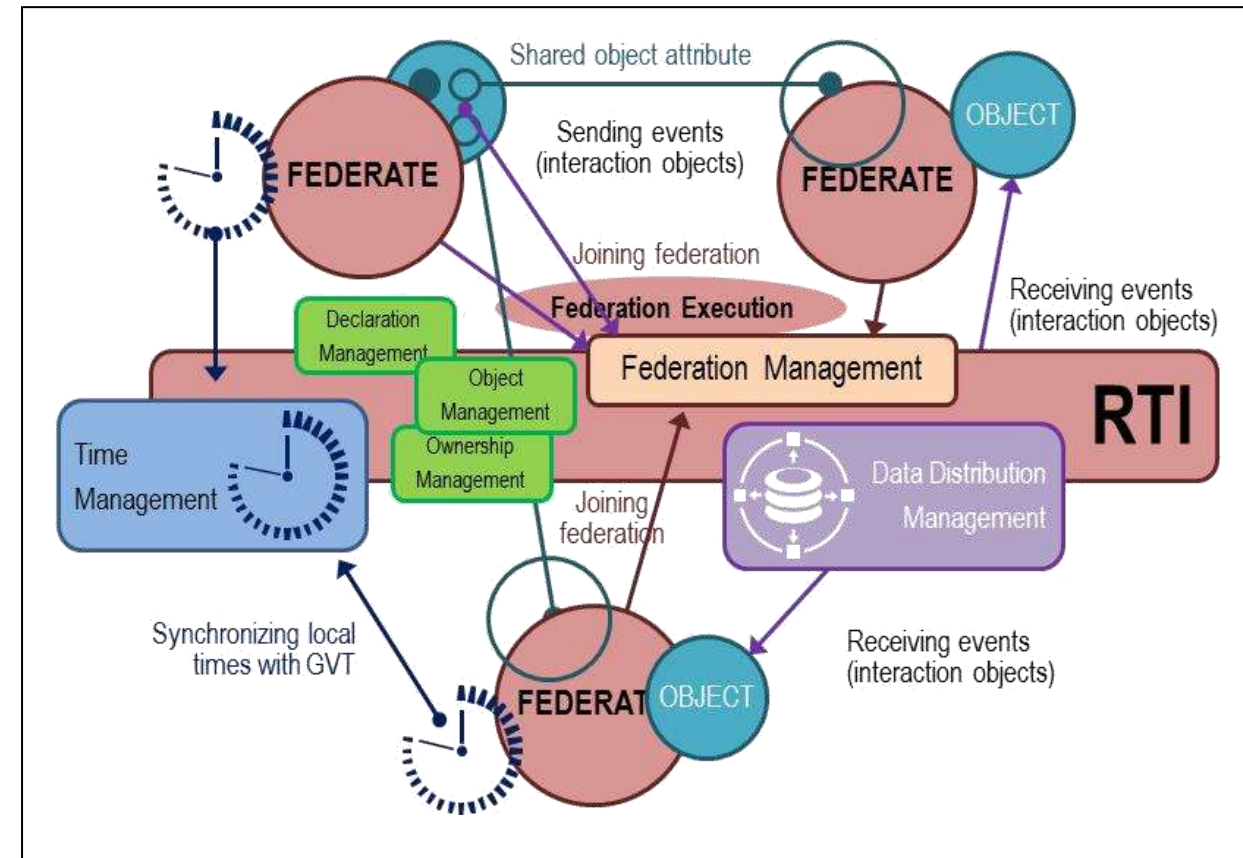
* - A Brain Computer Interface is a device that allows a person to control an external device using their brain signals. See: Advancements in Brain-machine Interfaces for Application in the Metaverse, Yang Liu, Ruibin Liu, Jinnian Ge 4, Yue Wang 3, PMCID: PMC11198002 PMID: 38919909, <https://pmc.ncbi.nlm.nih.gov/articles/PMC11198002/>



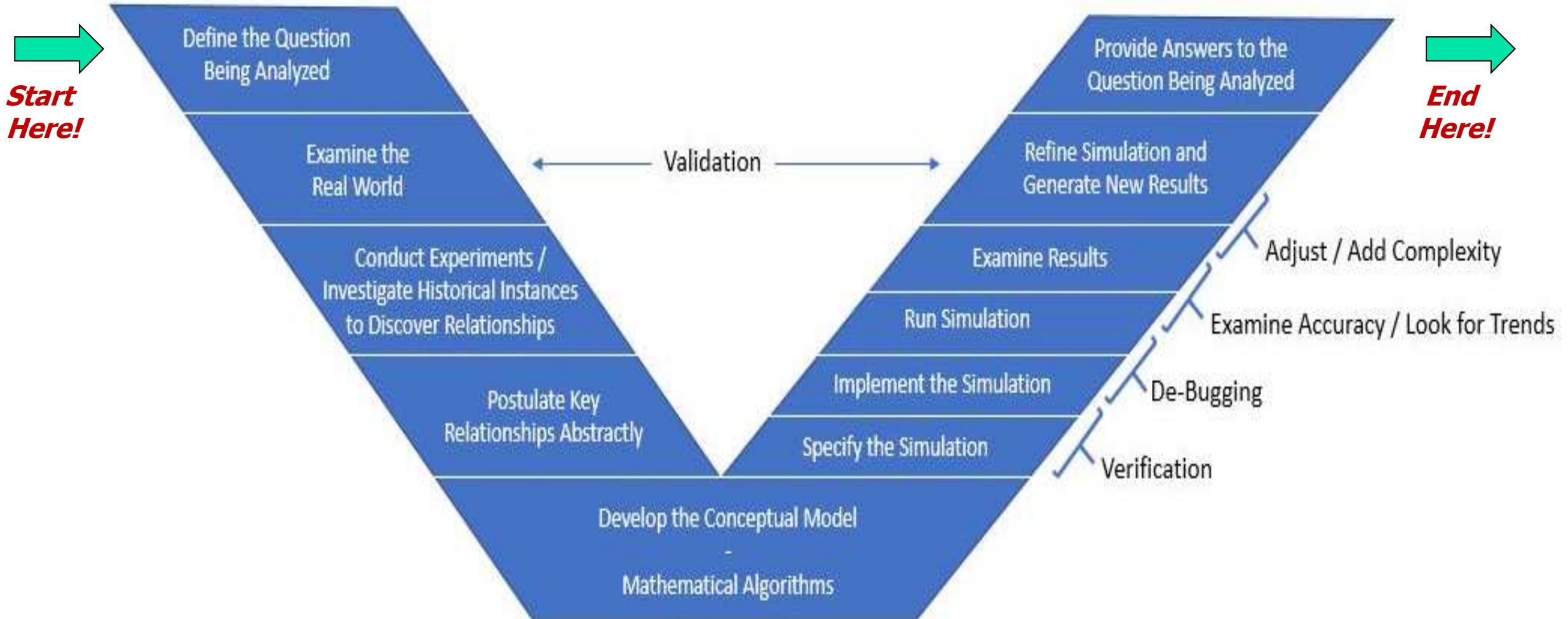
- Engineering principles and practices for developing and validating M&S systems; M&S standards; special models.

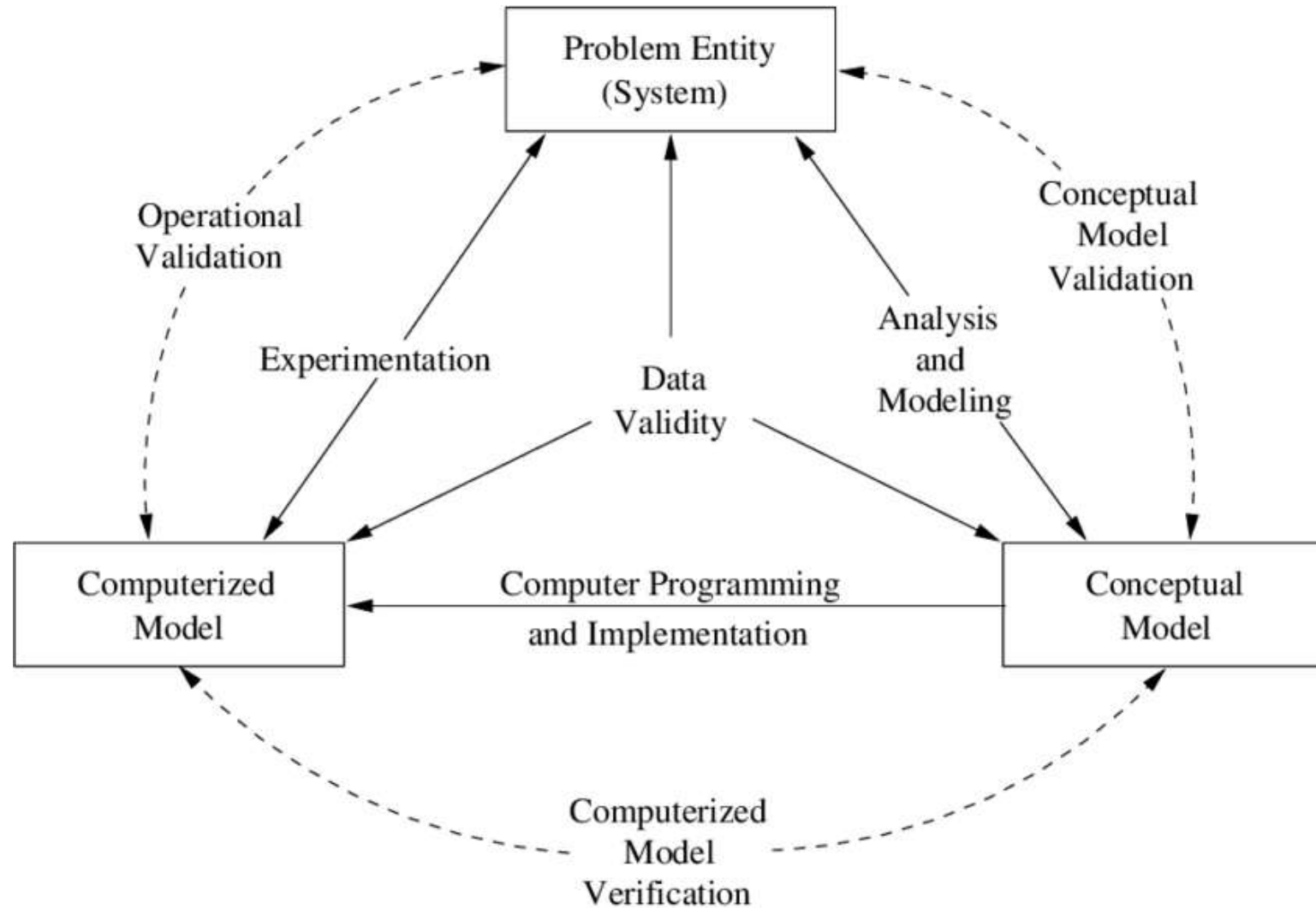
5. Simulation implementation

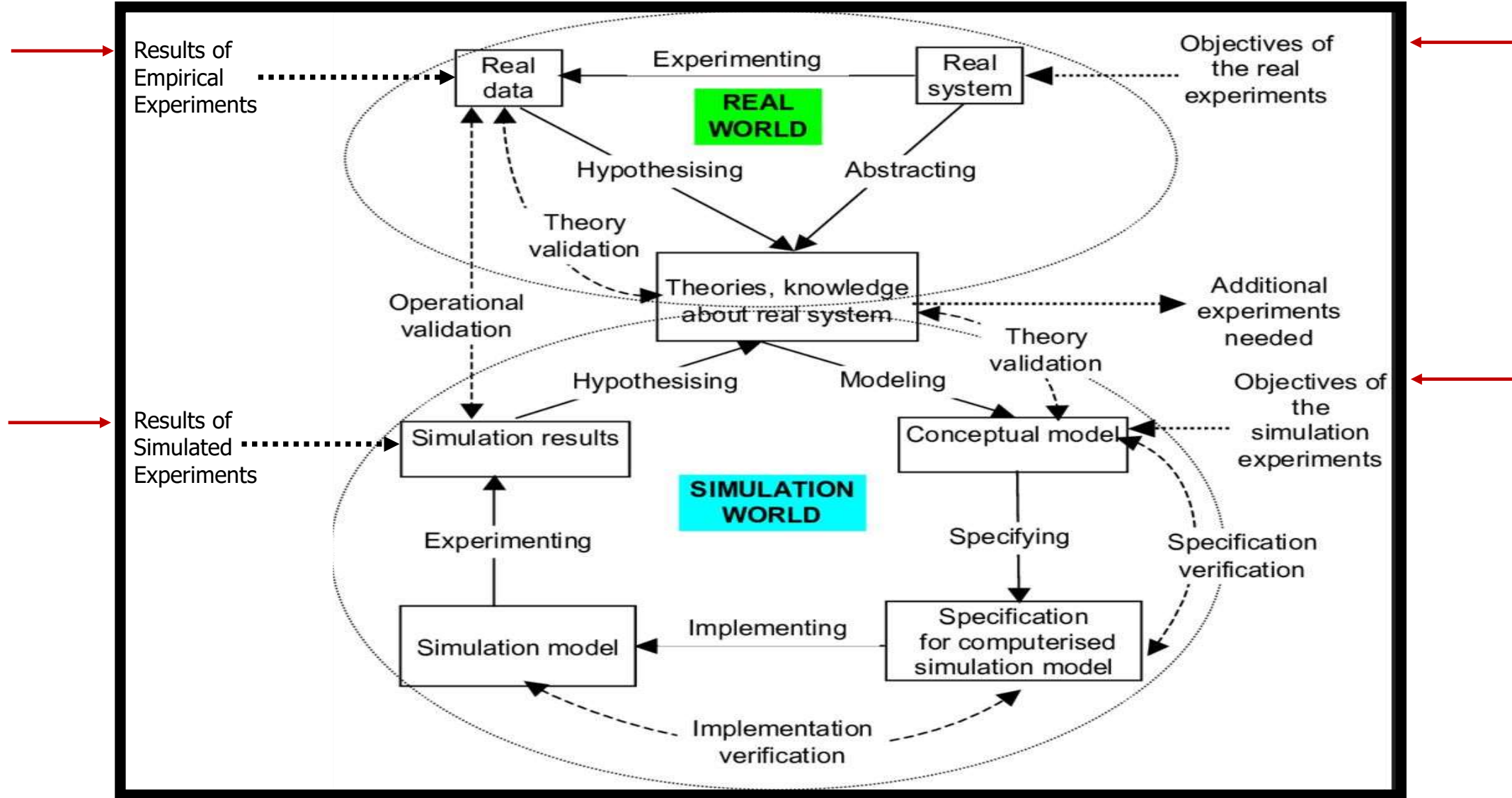
- 5.1 Modeling and simulation life-cycle
- 5.2 Modeling and simulation standards
- 5.3 Development processes
- 5.4 Conceptual modeling
- 5.5 Specialized languages
- 5.6 Verification, validation, and accreditation
- 5.7 Distributed simulation and interoperability
- 5.8 Virtual environments and virtual reality
- 5.9 Human-computer interaction
- 5.10 Semi-automated forces
- 5.11 Stimulation



High Level Architecture (HLA) - Components

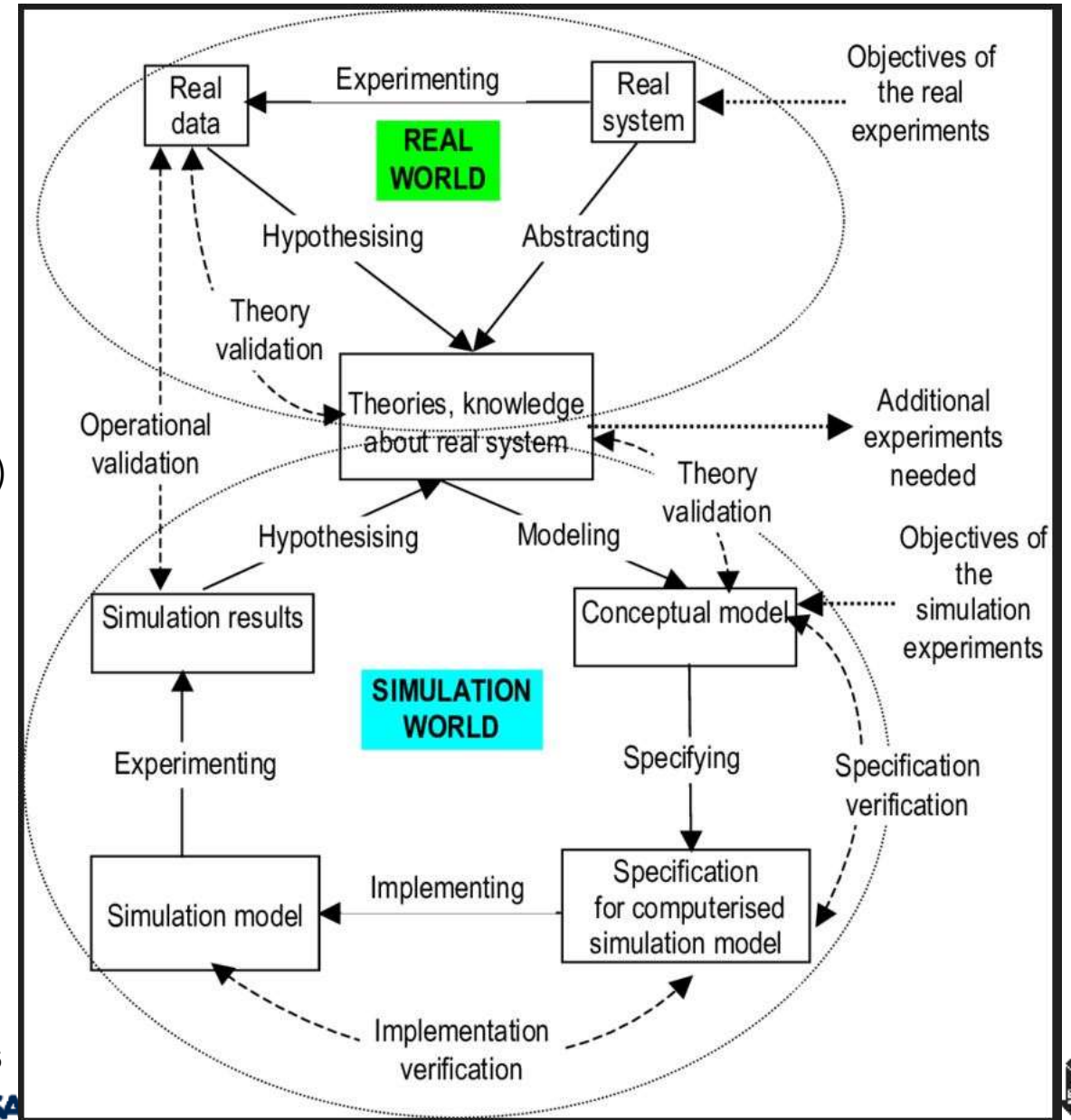


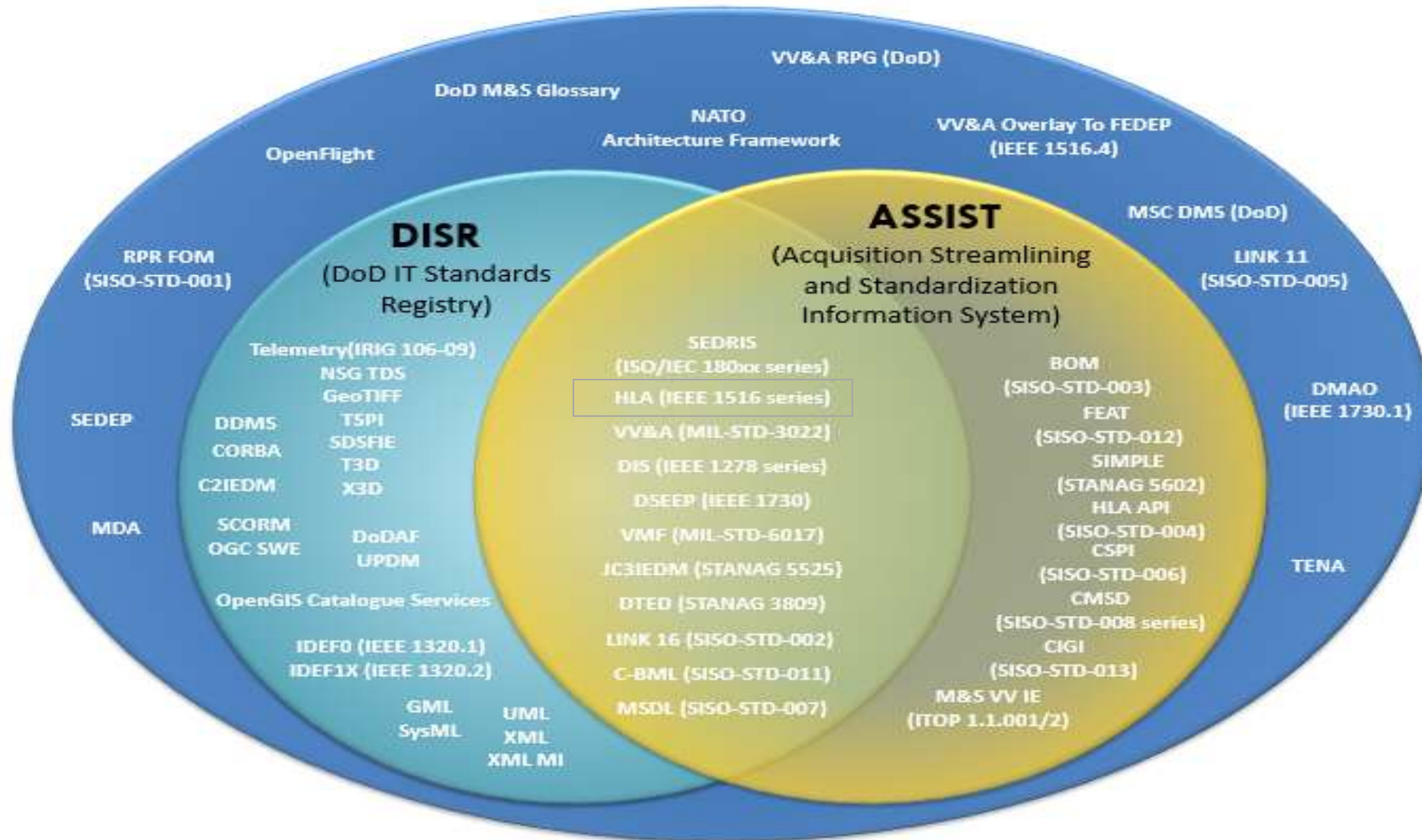






- Start with the real world
 - Columns of forces engaging in lines (Started early in the 17th Century - To Maximize Firepower*)
 - (Describe Linear Combat)
- Abstract / Hypothesize
 - Understand combat lethality / causality rates based on force numbers in linear arrangement
- Develop a Conceptual Model!
 - Each side starts with a defined number of forces
 - Forces can be specified regarding their ability to inflict damage (1:3)
 - Forces are constrained in their ability to move (flanking maneuvers are not allowed)
- Specify the Simulation Capability to be Developed
 - Deterministic / Non-Probabilistic
- Develop (Implement) the Simulation System
 - Difference Equations
- Run / Execute the Simulation
 - Generate Output
- Analyze the Results / Outputs
 - Look for Correlations, Trends, Causality, etc.
- Operational Validation of the Simulation
 - See, for instance, "Exploring the Validation of Lanchester Equations for the Battle Of Kursk," John A. Dinges, NPS, June 2001



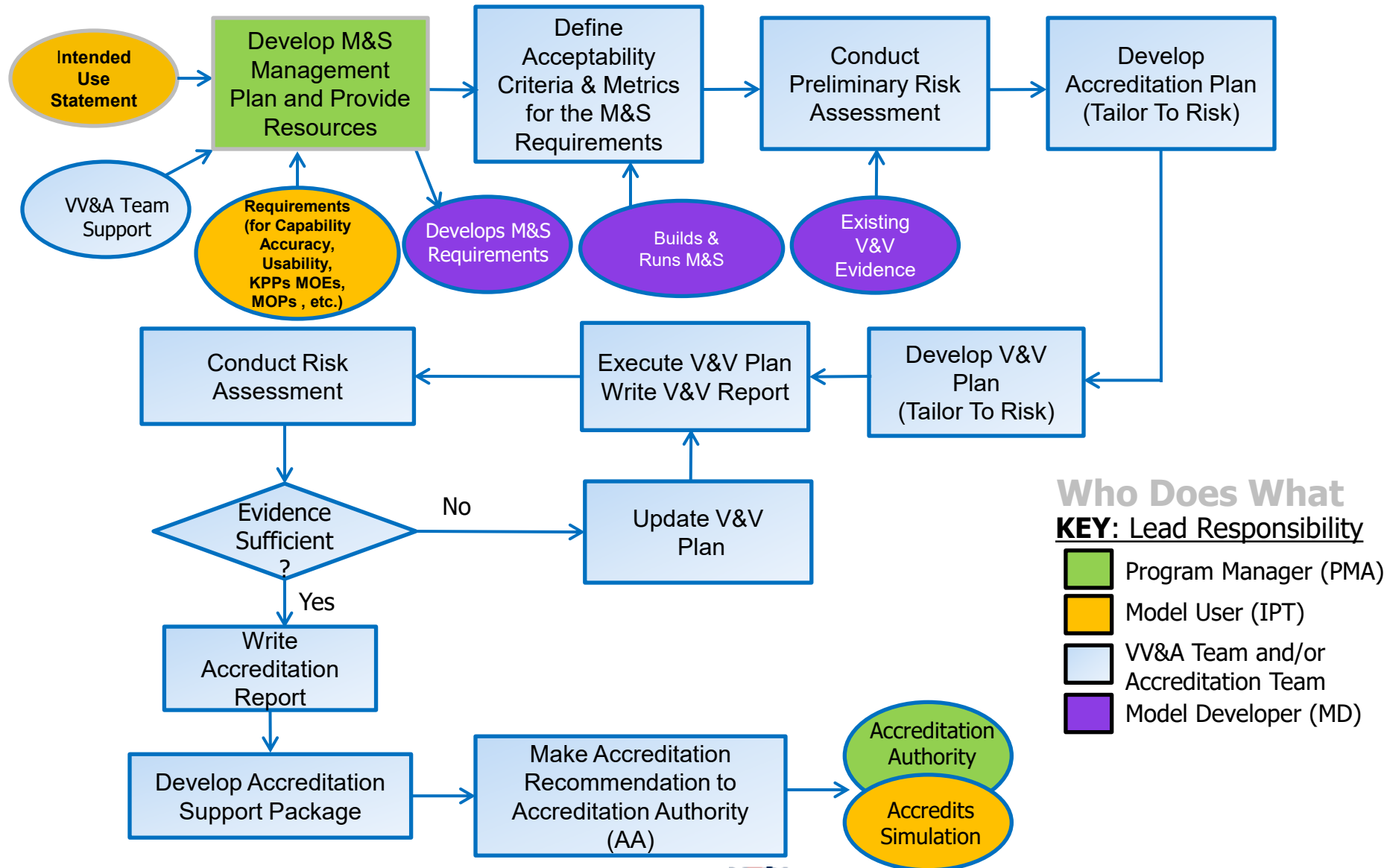




- **Verification** is the process of determining that a model implementation accurately represents the developer's conceptual description and specifications.
 - It answers the question, "Did we build it correctly?"

- **Validation** is the process of determining the manner and degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model, and of establishing the level of confidence that should be placed on the results of its use.
 - It answers the question, "Did we build the right thing?"

- **Accreditation** is the formal endorsement ~~certification~~ that a model or simulation is acceptable to be used for a specific purpose.¹ A recognized subject matter expert in the field can accomplish accreditation.
 - Accreditation answers the question, "Does it meet my needs?"





- The validity of the system refers to the relation between the model, simulation, and real world
 - Often thought of as the degree to which a model faithfully represents its system counterpart
- Types of validity:
 - Replicative validity requires that the model and system agree at the I/O level
 - Predictive validity requires the ability to predict new / emergent unseen behavior
 - Structural validity requires that the M&S mimics step-by-step, component-by-component fashion the way in which the system does its transitions.
- Validation is the process of testing the M&S for validity
 - Face Validation - Subject Matter Expert (SME) expectations
 - Benchmarking - Another simulation with established credibility
 - Results Validation - Test Data, Operational Data, Historical Data
- Validation techniques have well-known limitations:
 - Disagreements among SMEs
 - Uncertain benchmark simulation credibility or inadequate fidelity
 - Test data availability, limitations, and cost

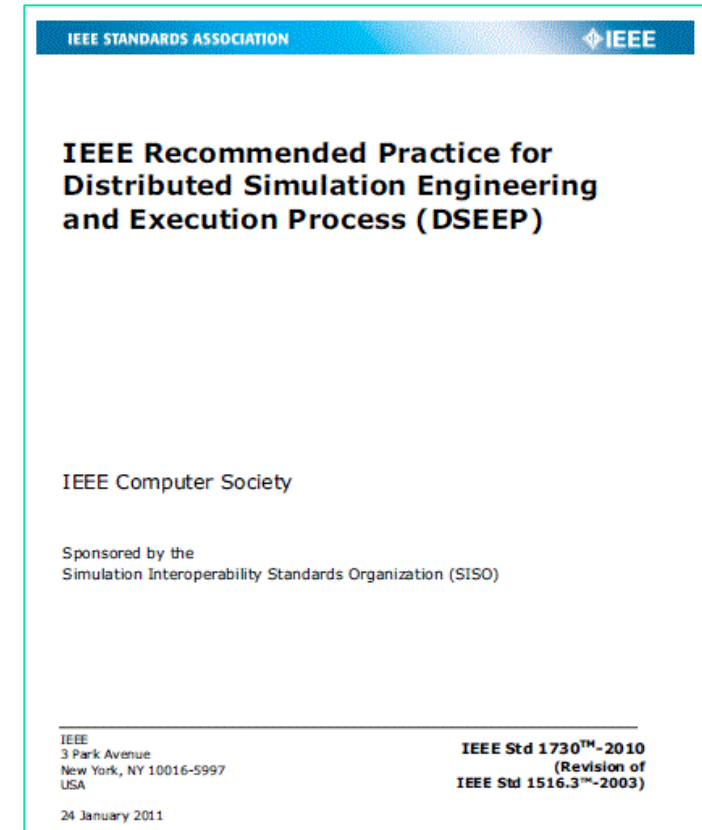


AKA - Registration



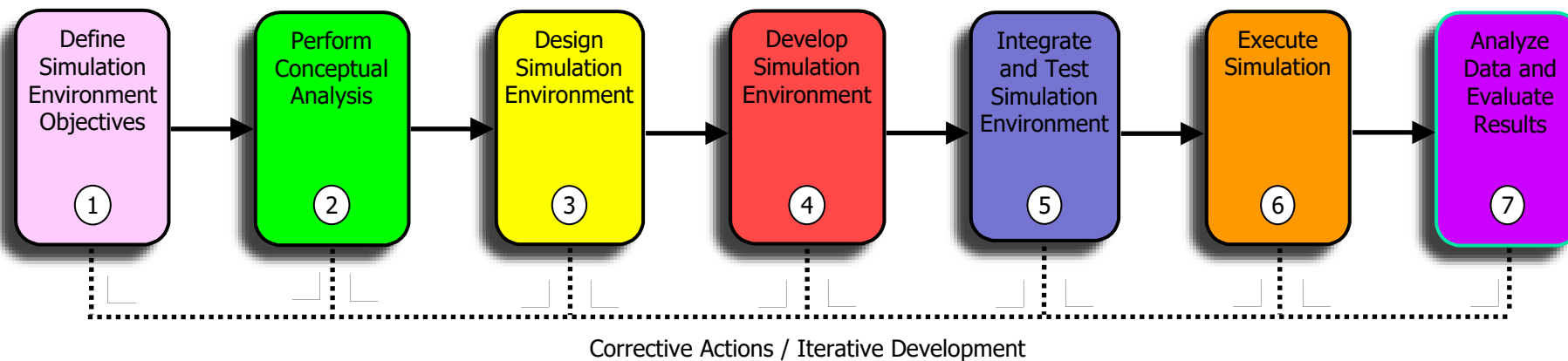
Distributed Simulation Engineering and Execution Process (DSEEP)

- An architecture-neutral, high-level process framework into which the lower-level systems engineering practices native to any distributed simulation user can be easily integrated
- Applies to federation engineering in a single-architecture environment





- The DSEEP was developed based on several, widely-adopted, authoritative systems engineering processes
- These processes were adapted and extended to address engineering requirements unique to distributed simulations





- Technical infrastructures, M&S resources, and organizations supporting the development and use of M&S.
- 6. Supporting tools, techniques, and resources
 - 6.1 Major simulation infrastructures
 - 6.2 M&S resource repositories
 - 6.3 M&S organizations



<https://nmsg.sto.nato.int/themes/msaas>



- Business of M&S and M&S as a business; professional conduct for M&S practitioners; M&S workforce.

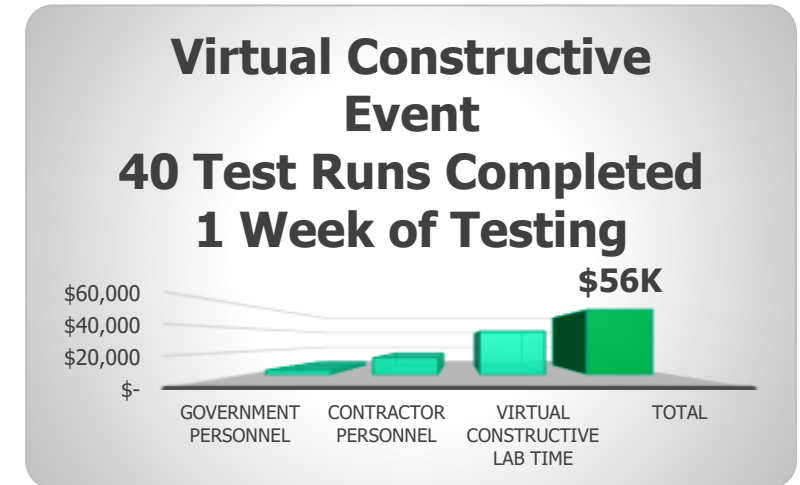
7. Business and management of M&S

7.1 Ethics and Principles for M&S practitioners

7.2 Management of M&S Projects and Processes

7.3 M&S Workforce Development

7.4 M&S Business Practice and Economics





1. PERSONAL DEVELOPMENT & PROFESSION

As a simulationist, I will:

- 1.1 Acquire and maintain professional competence and attitude.
- 1.2 Treat fairly employees, clients, users, colleagues, and employers.
- 1.3 Encourage and support new entrants to the profession.
- 1.4 Support fellow practitioners and members of other professions who are engaged in modeling and simulation.
- 1.5 Assist colleagues to achieve reliable results.
- 1.6 Promote the reliable and credible use of modeling and simulation.
- 1.7 Promote the modeling and simulation profession; e.g., advance public knowledge and appreciation of modeling and simulation as well as clarify and counter false or misleading statements.

2. PROFESSIONAL COMPETENCE

As a simulationist, I will:

- 2.1 Assure product and/or service quality by the use of proper methodologies and technologies.
- 2.2 Seek, utilize, and provide critical professional review.
- 2.3 Recommend and stipulate proper and achievable goals for any project.
- 2.4 Document simulation studies and/or systems comprehensibly and accurately to authorized parties.
- 2.5 Provide full disclosure of system design assumptions and known limitations and problems to authorized parties.
- 2.6 Be explicit and unequivocal about the conditions of applicability of specific models and associated simulation results.
- 2.7 Caution against acceptance of modeling and simulation results when there is insufficient evidence of thorough validation and verification.
- 2.8 Assure thorough and unbiased interpretations and evaluations of the results of modeling and simulation studies.

3. TRUSTWORTHINESS

As a simulationist, I will:

- 3.1 Be honest about any circumstances that might lead to conflict of interest.
- 3.2 Honor contracts, agreements, and assigned responsibilities and accountabilities.
- 3.3 Help develop an organizational environment that is supportive of ethical behavior.
- 3.4 Support studies that will not harm either humans (current and future generations) or the environment.

4. PROPERTY RIGHTS & DUE CREDIT

As a simulationist, I will:

- 4.1 Give full acknowledgment to the contributions of others.
- 4.2 Give proper credit for intellectual property.
- 4.3 Honor property rights, including copyrights and patents.
- 4.4 Honor privacy rights of individuals and organizations as well as confidentiality of the relevant data and knowledge.

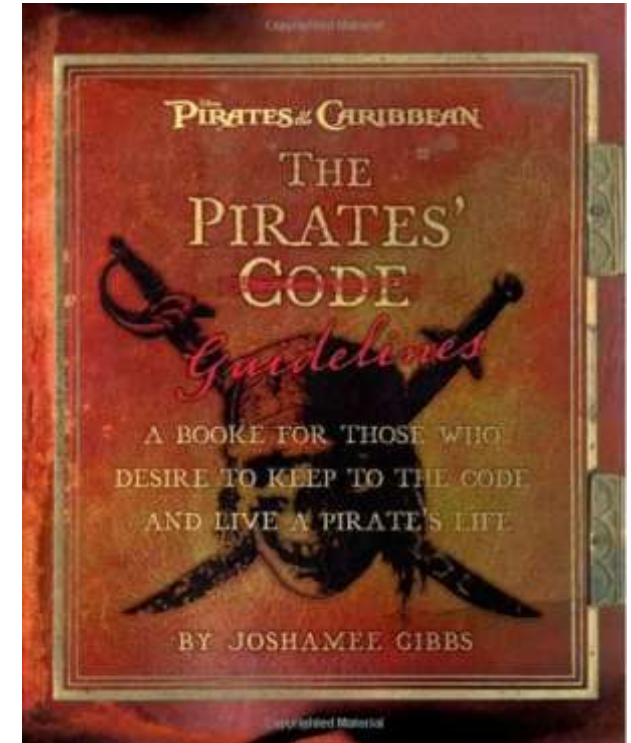
5. COMPLIANCE WITH THE CODE

As a simulationist, I will:

- 5.1 Adhere to this code and encourage other simulationists to adhere to it.
- 5.2 Treat violations of this code as inconsistent with being a simulationist.
- 5.3 Seek advice from professional colleagues when faced with an ethical dilemma in modeling and simulation activities.
- 5.4 Advise any professional society that supports this code on desirable updates.

Signature

Date



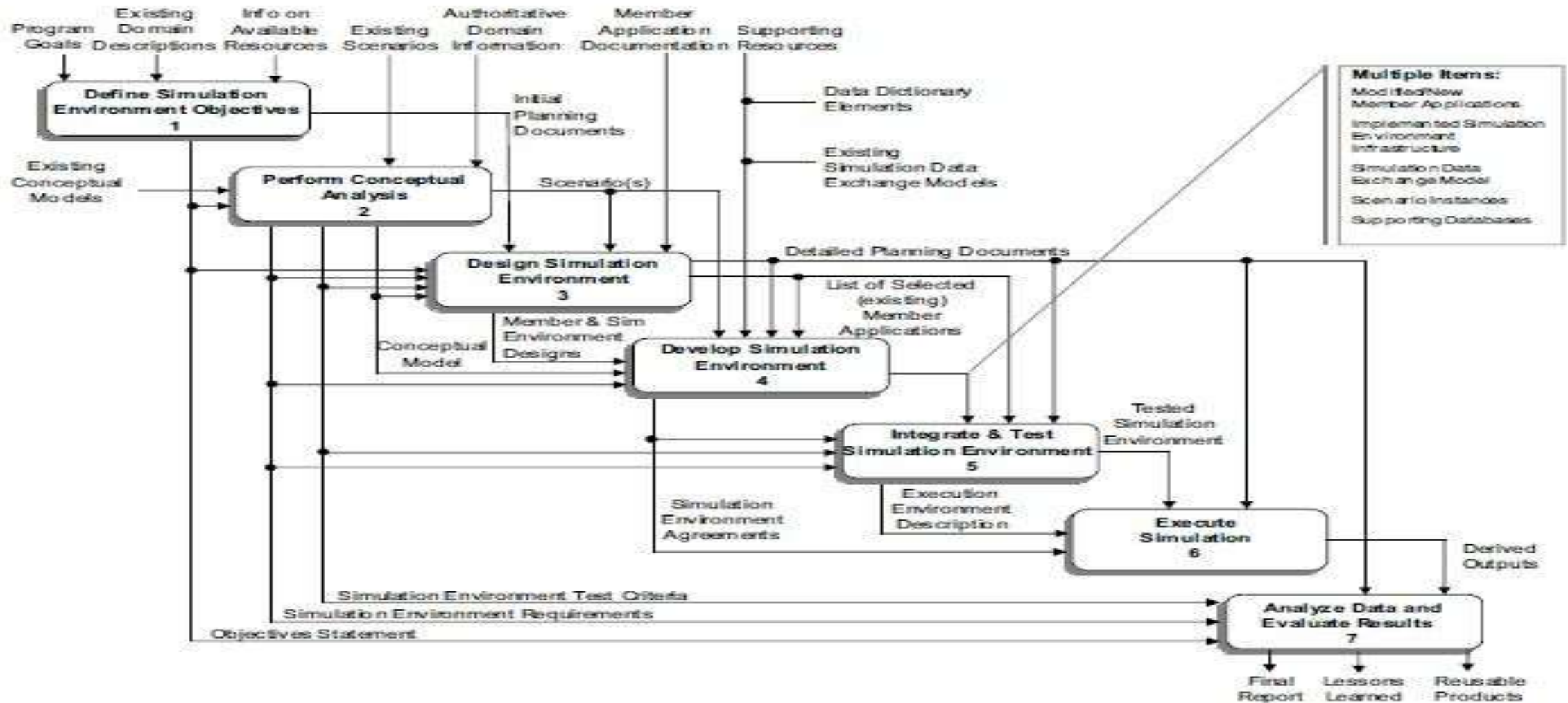
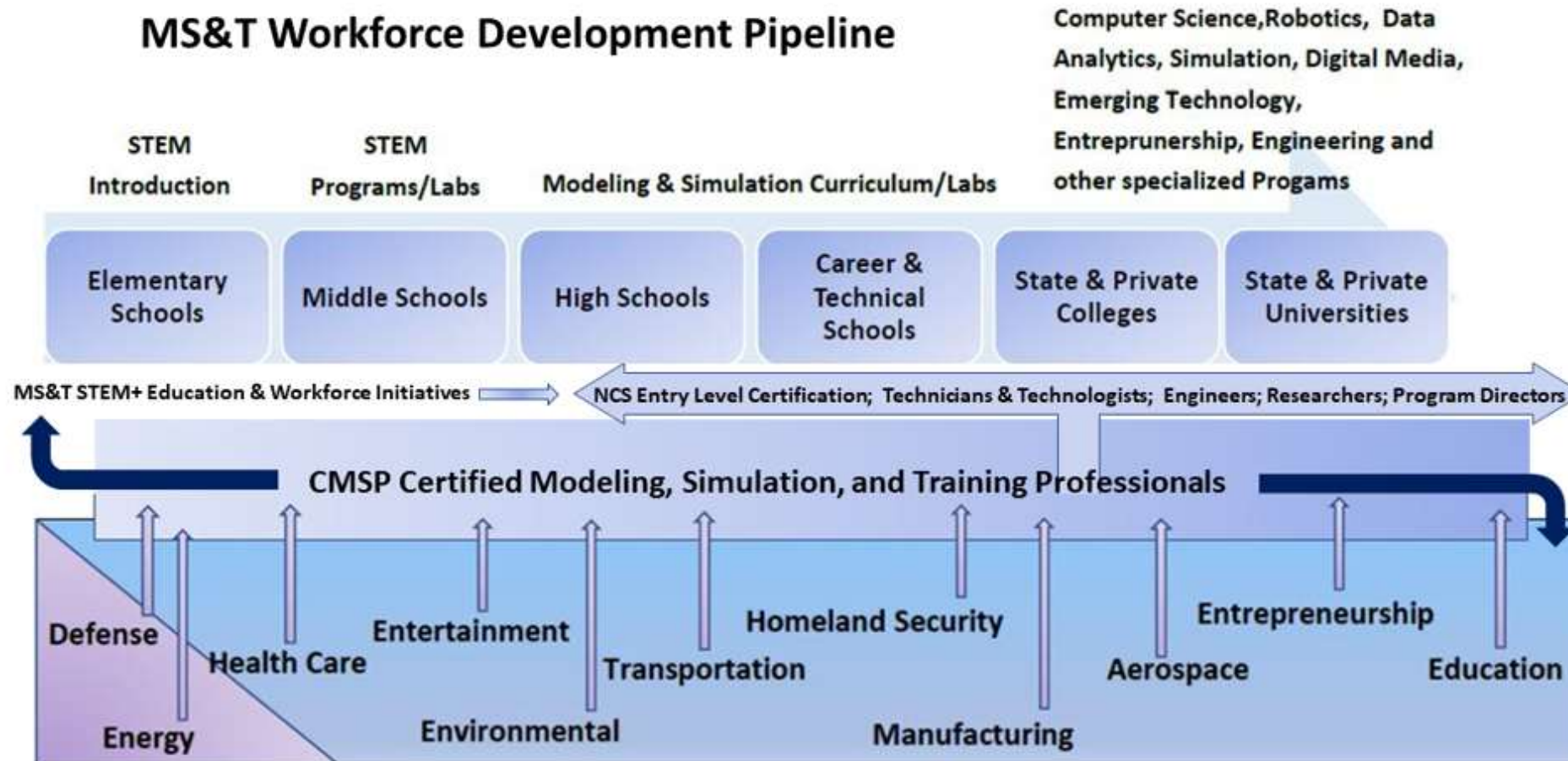


Figure 2—Distributed Simulation Engineering and Execution Process (DSEEP), detailed product flow view



The National Modeling, Simulation, and Training (MS&T) Industry

MS&T Workforce Development Pipeline

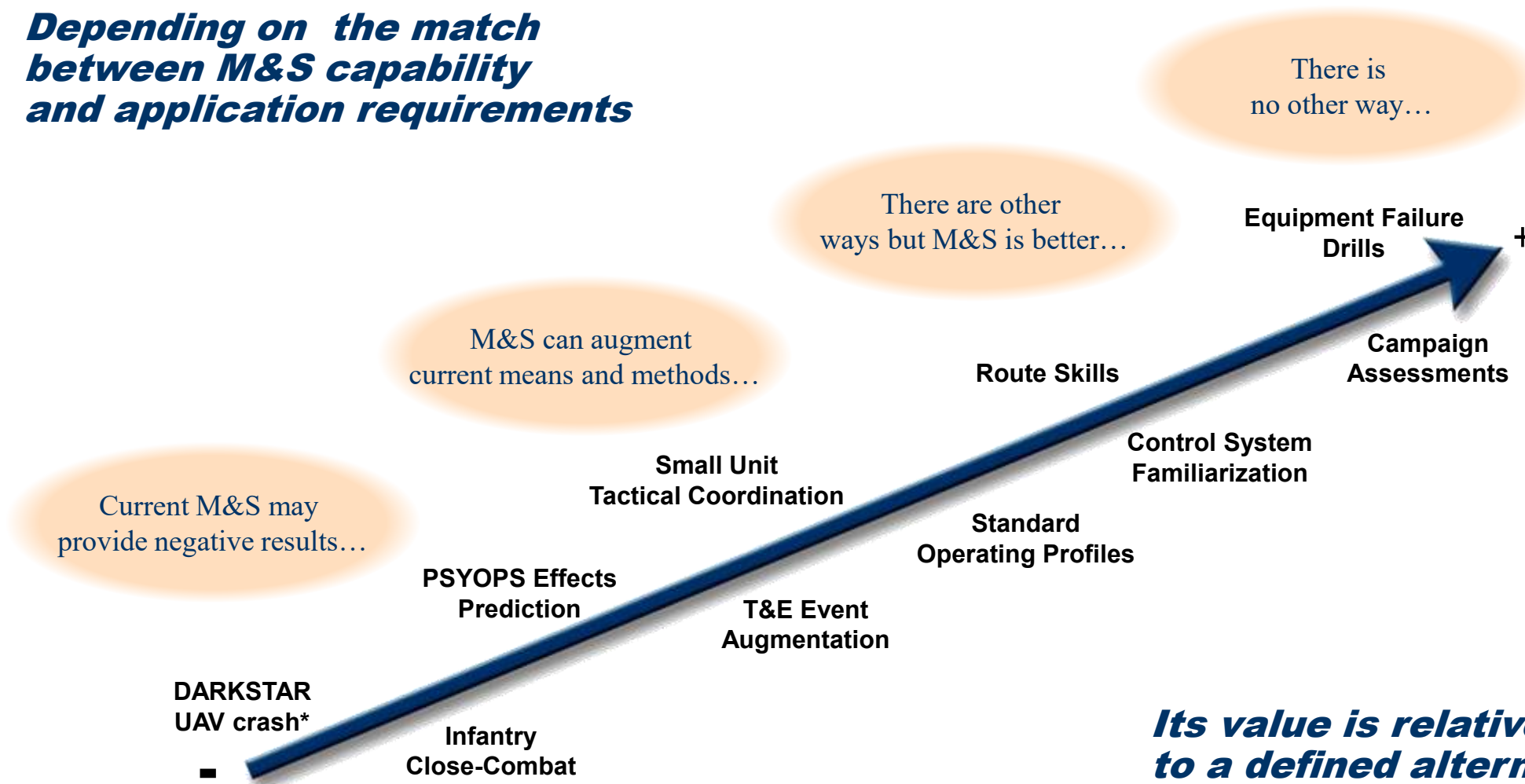




*See I/ITSEC
M&S RIO
Tutorial for
More*

➤ M&S Value Varies...

***Depending on the match
between M&S capability
and application requirements***





- Non-M&S topics with which M&S professionals should have some familiarity.

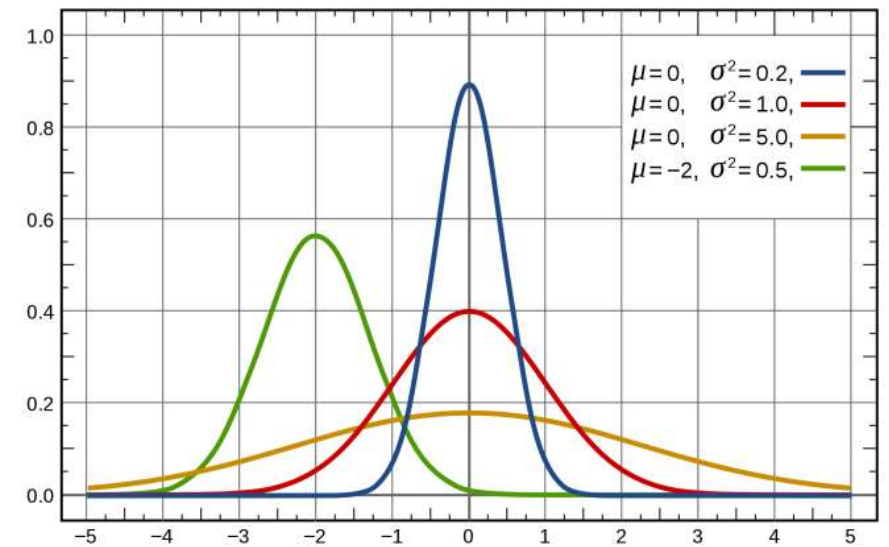
8. Related Communities of Practice and Disciplines

8.1 Statistics and Probability

8.2 Mathematics

8.3 Software Engineering and Development

8.4 Systems Science and Engineering

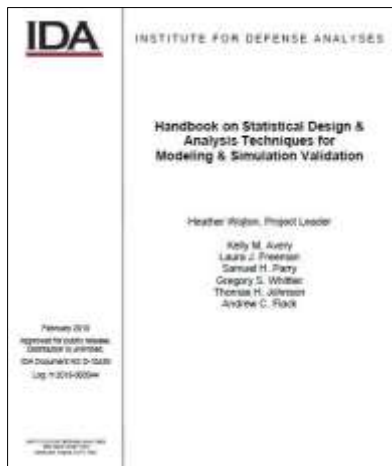




- Especially in Validation of Simulations, Statistics is an Essential Tool

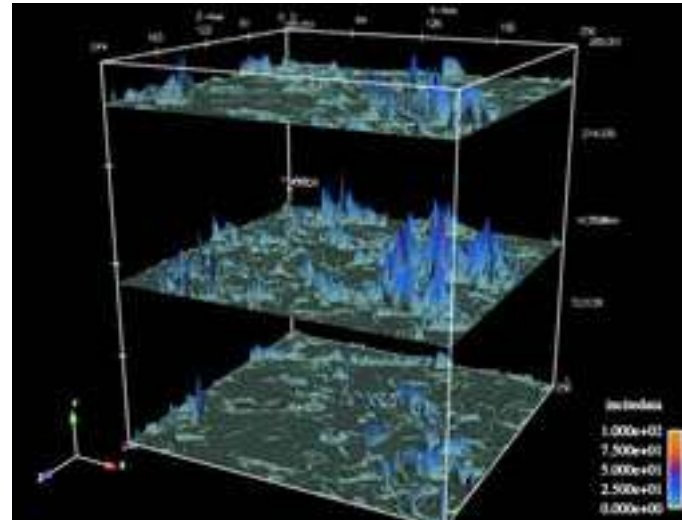
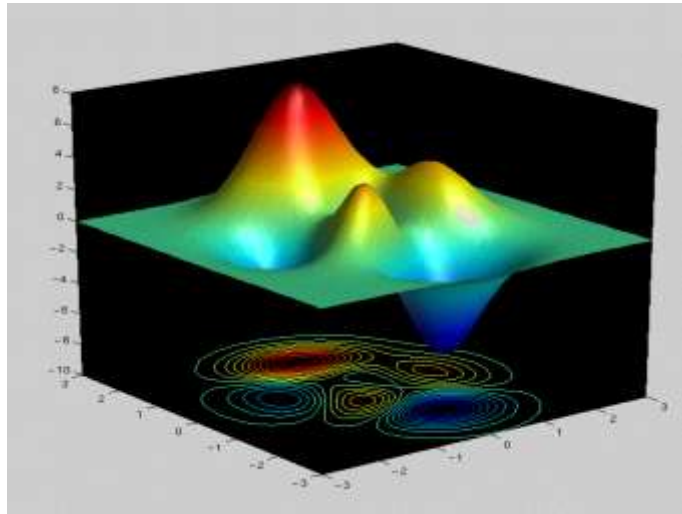
Table 1. Correlating Statistical Concepts to the VV&A Process

VV&A Information	Process Step	Statistical Concepts
M&S Requirements and Intended Use	1 – 4	Response variables Factor space Stochastic vs. deterministic models
Data Requirements	5	Design for Computer Experiments (Chapter 3) Classical Design of Experiments (Chapter 3)
Iterate Model-Test-Model	6	Design for Computer Experiments (Chapter 4) Classical Design of Experiments (Chapter 4) Variation Analysis & Statistical Emulation (Chapter 3) Comparison to M&S runs (Chapter 3) Calibration (Chapter 4)
Verification Analysis	7	Parametric Analysis (Chapter 3)
Validation Analysis	8	Parametric Analysis (Chapter 3) Comparison of live and M&S data (Chapter 3)
Quantify Uncertainty	8 – 9	Hypothesis Testing and Interval Estimation (Chapter 3)





- Simulations generate incredible amounts of data; interpreting this data is often aided by using information visualization, sometimes called scientific visualization



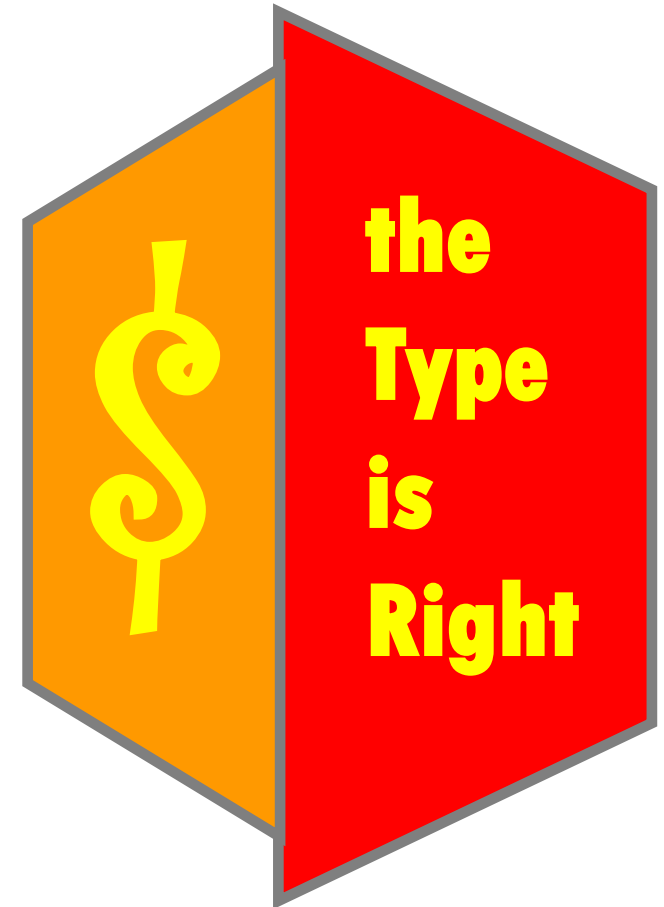


- Learning Objectives
- Introductions
 - Acknowledgements
- Role of M&S, Certification, CMSP
- CMSP
 - Certification Levels
 - Education and Experience
 - Exam Philosophy and Overview
 - Exam Specifics
 - Tracks and Topics / Subtopics
 - Tips, Techniques, and Timeline
- Overview of Topics / Subtopics
 - M&S Types, Applications,...



- Summary of Types of M&S
 - The Type is Right Game
- Certification Exam
 - Sample Questions
- Review
 - Topics
 - Count-Down Game
- CMSP
 - Context
 - Current Events
- Summary of Key Terms and Concepts
 - Crossword Puzzle Game
- Course Evaluations

- An M&S Image will be flashed on the screen and then disappear
- You need to decide what Type of M&S system it is!
- Is it a simulation, emulation, simulator, appended trainer, game, etc.
- Win a Prize!
- Load Game File.....
- ***GO!***



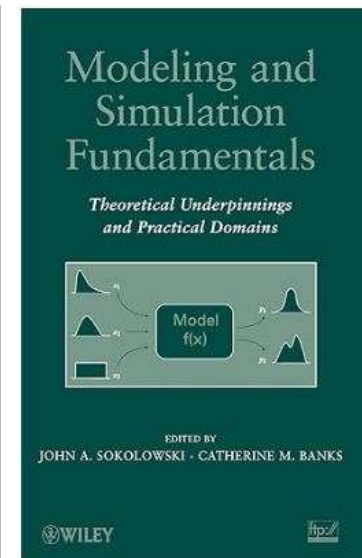
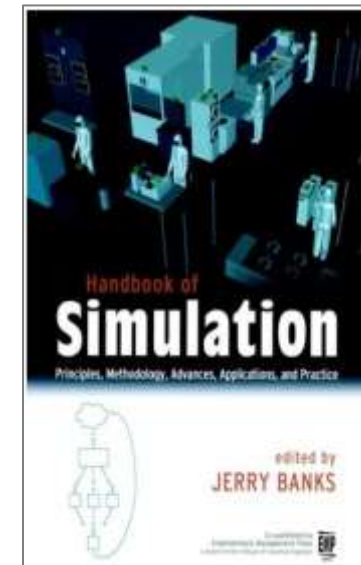
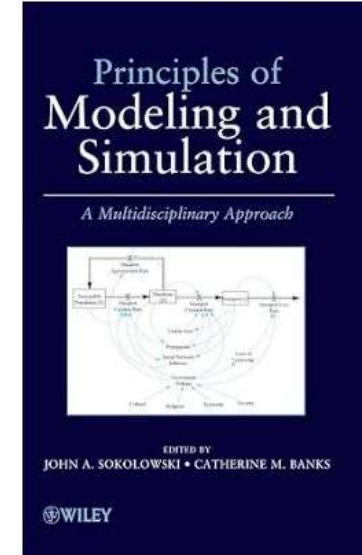
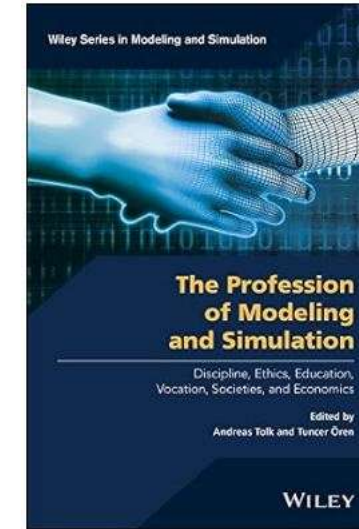


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- Number
 - Total: 1,000+ questions
 - Selection: Varies by CMSP Level
- Sources
 - Each question based on a specific source
 - Sources are all published, publicly available



**Intern**

What type of simulation involves real people operating simulated systems in a synthetic environment?

- A. Emulative Simulation
-  B. Virtual Simulation
- C. Virtualized System
- D. Constructive Simulation

Live Simulation: Real people employing real systems in a non-operational role or location (e.g., on a training range)

Virtual Simulation: Real people operating simulated systems in a synthetic environment

Constructive Simulation: Simulated people operating simulated systems in a simulated environment

**Apprentice**

What type of simulation is often based on differential equations?

- A. Discrete event simulation
- B. Continuous simulation
- C. Monte Carlo simulation
- D. Cellular automata simulation

A differential equation is any equation which contains derivatives (which calculates the rate of change at a given point)

There is one differential equation that everybody probably knows, that is Newton's Second Law of Motion. If an object of mass M is moving with acceleration A and being acted on with force F then Newton's Second Law tells us that $F = MA$

**Practitioner**

Which of the following phenomena is generally considered to be a suitable application of ensemble modeling?

- 
- A. Weather forecasting
 - B. Ballistics calculation
 - C. Queue optimization
 - D. Image generation

Ensemble modeling is a process where multiple diverse models are created to predict an outcome, often by using many different modeling algorithms

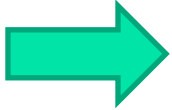
An ensemble weather forecast is a set of forecasts that present the range of future weather possibilities. Multiple simulations are run, each with a slight variation of its initial conditions and with slightly perturbed weather models.



Master

Which of the following terms is best defined as "uncertainty associated with a phenomenon or event modeled as random because there is no better way to characterize it as known"?

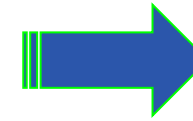
- A. Epistemic uncertainty
- B. Exponential uncertainty
- C. Ontologic uncertainty
- D. Aleatory uncertainty



- **Epistemic uncertainty.** The potential inaccuracy in any phase or activity of the M&S process that is due to a lack of knowledge or to intentional approximations applied by the simulationist. It is reducible by model improvements or through the use of better measuring techniques to assess model parameters.
- **Exponential uncertainty.** Uncertainty Calculation in exponential function, $y = 10^x$
- **Ontological uncertainty.** Different parties in the same interactions having different conceptualizations about what kinds of entities inhabit their world.
- **Aleatory uncertainty.** The inherent variation associated with a physical system or the environment under consideration, e.g., the variation of geometric and or material properties within a manufacturing process. It is stochastic and irreducible below a certain threshold.
- P. F. Reynolds, "The Role of Modeling and Simulation?", in J. A. Sokolowski and C. M Banks, (Editors), Principles of Modeling and Simulation: A Multidisciplinary Approach, John Wiley and Sons, Hoboken NJ, 2009, pp. 25-43.



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 - Rapid Fire Game
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- A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process
- To an observer B , an object A^* is a model of an object A to the extent that B can use A^* to answer questions that are of interest about A
- Representation of something else, normally a “real-world” system
- Some aspects of the modeled system are represented in the model, others not

Models

Physical model
Represents:
Appearance
Abstracts:
Size



Physical model
Represents:
Aerodynamics
Omits:
Ailerons



[Bollay, 1951]

Physical model
Represents:
Flight
Omits:
Appearance



Simuland
P-51D Mustang

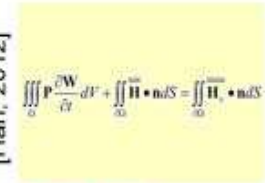
Models

Visual model
Represents:
Appearance
Omits:
Flight

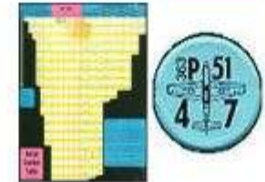


Functional model
Represents:
Aerodynamics
Omits:
Appearance

[Han, 2012]



Aggregate model
Represents:
Combat
Abstracts:
Pilot skill





- Since the 90s, there have been a set of technical goals pursued by empowered organizations - of many types!
- Progress has been made in all (e.g., ships in one sim no longer hover above waves provided by another), yet there is still much to do in:
 - **Composability:** The degree to which an M&S user can effectively develop, from a pallet of components, an executable simulation to address a question of interest.
 - **Interoperability:** The ability of an M&S system to provide services to and accept services from others, and to use these services to operate effectively together.
 - **Reuse:** Using again, in whole or part, existing M&S tools, data, or services.
 - **Scalability:** The ability of a simulation to maintain time and spatial consistency as the number of entities and accompanying interactions increase.



- A set of 5 questions on M&S will be presented
- You have 8 seconds to answer
- Only those getting the previous question right will advance to the next round
- Prize going to the last remaining contestant
- Load Game File.....
- **GO!**





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- Role of M&S, Certification, CMSP
- CMSP
 - Certification Levels
 - Education and Experience
 - Exam Philosophy and Overview
 - Exam Specifics
 - Tracks and Topics / Subtopics
 - Tips, Techniques, and Timeline
- Overview of Topics / Subtopics
 - M&S Types, Applications,...

- Summary of Types of M&S

- The Type is Right Game

- Certification Exam

- Sample Questions

- Review

- Topics

- Rapid Fire Game

CMSP

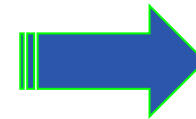
- Context

- Current Events

- Summary of Key Terms and Concepts

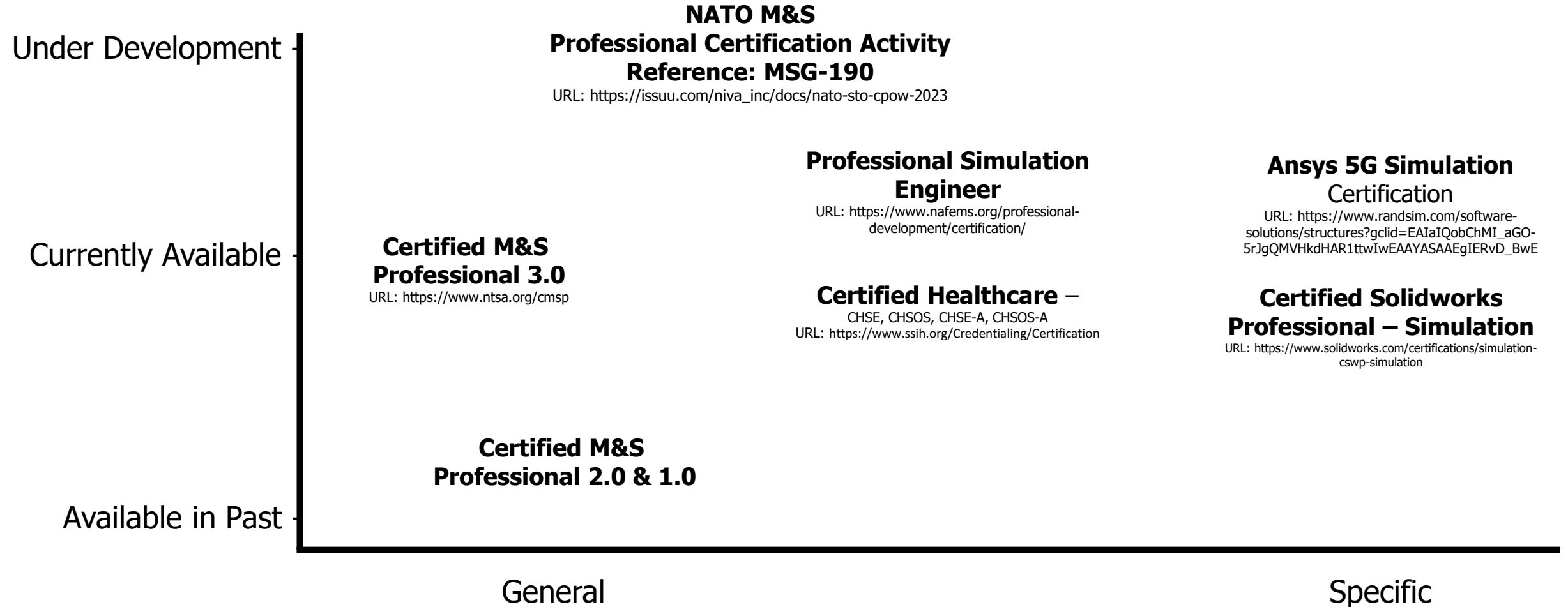
- Crossword Puzzle Game

- Course Evaluations





➤ Other M&S Certifications and Initiatives



CHSE: Certified Healthcare Simulation Educator, CHSOS: Certified Healthcare Simulation Operations Specialist, A: Advanced



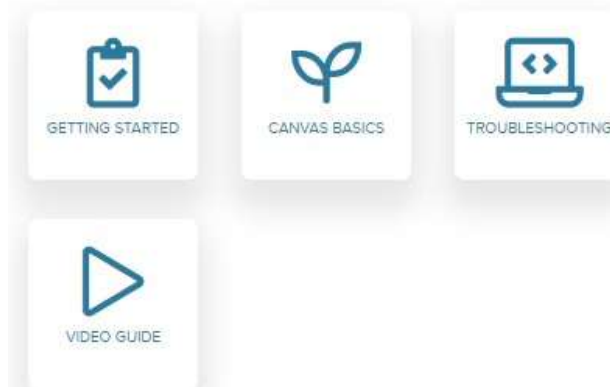
- CMSP Evolution: Version 1.0 in 2001, 2.0 in 2010, 3.0 Released

- CMSP 3.0
 - Now Includes Four Integrated Levels – Intern, Apprentice, Practitioner, and Master
 - Streamlines the Processes and Employs a Learning Management System
 - Updates the Examination
 - Creating a Vibrant Community of Practice
 - Quarterly Newsletter
 - Conference Presence
 - MODSIM
 - TSIS
 - DAF M&S Summit
 - Etc.



- The platform we are using is called Canvas
- It's a learning management system used by UCF and many others
- CMPS 3.0 is built like a course on the platform
- Here is a link to a short "Student tour" video
 - <https://community.canvaslms.com/t5/Video-Guide/Canvas-Overview-Students/ta-p/383771>

View General Canvas Guides



View Resources for your Canvas Role



Top 5 Resources

- How do I set my Canvas notification preferences as a student?
- How do I generate a pairing code for an observer as a student?
- How do I upload a file as an assignment submission in Canvas?
- How do I reply to a discussion as a student?
- How do I submit an online assignment?

Browser/iOS Compatibility

Desktop Browsers

View full details

- Chrome 90 and 91
- Firefox 89 and 90
- Edge 90 and 91
- Respondus Lockdown Browser
- Safari 13 and 14

Mobile Browsers

View limited support guidelines

- Latest version of Safari (iOS) and Chrome (Android)

Mobile Apps

- Android 6.0 or later
- iOS 13.0 or later

Guide Resources

Download PDF Manuals
View Guides User License



What additional skills or knowledge areas should the CMSP certification cover to support M&S professionals?

- Expand simulation theory (e.g. including types of fidelity to match user needs and outcomes, theory of representation), data visualization (for different audiences so that the results of simulation can be adequately presented and support better decision-making based on those results; this requires user psychology and understanding of perception),
- M&S ethics (this is one of the best things currently in CMSP--build on it!), most of all-->simulation based-training
- The program should include advanced skills and knowledge tailored to VR training and simulation
- Human factors and ergonomics should be emphasized to create user-friendly simulations that enhance safety and learning retention. Industry-specific expertise in areas like nuclear energy is essential, enabling the modeling of SMR operations, safety protocols, and emergency scenarios.
- Scenario development and storyboarding would enhance the narrative quality of training, fostering better engagement and decision-making.
- The certification should also focus on advanced physics and environmental simulation to replicate complex conditions, such as weather, radiation, and object interactions, critical for maritime, aviation, and nuclear applications.
- A strong understanding of data analytics is vital for assessing performance metrics, refining simulations, and building feedback systems to measure training effectiveness.
- Professionals should also be versed in industry standards and best practices, ensuring compliance with safety and quality benchmarks from organizations like IEEE and ISO.
- Incorporating emerging technologies like AI, machine learning, digital twins, and IoT would future-proof M&S professionals, helping them integrate adaptive, real-time elements into simulations.
- Additionally, skills in project management would support efficient development timelines and resource allocation, while a focus on multidisciplinary collaboration would enable professionals to effectively communicate with SMEs, developers, and stakeholders



- Education, Certification, Institutionalization
 - 3.0 is aggressively working to support the Expansion of Our Profession
- CMSP Newsletter now being distributed regularly
- Volunteers are being sought for
 - Mentors
 - Committee Members
 - Exam Question Generators
- CMSP 3.0 looks forward to assisting with the Institutionalization of M&S





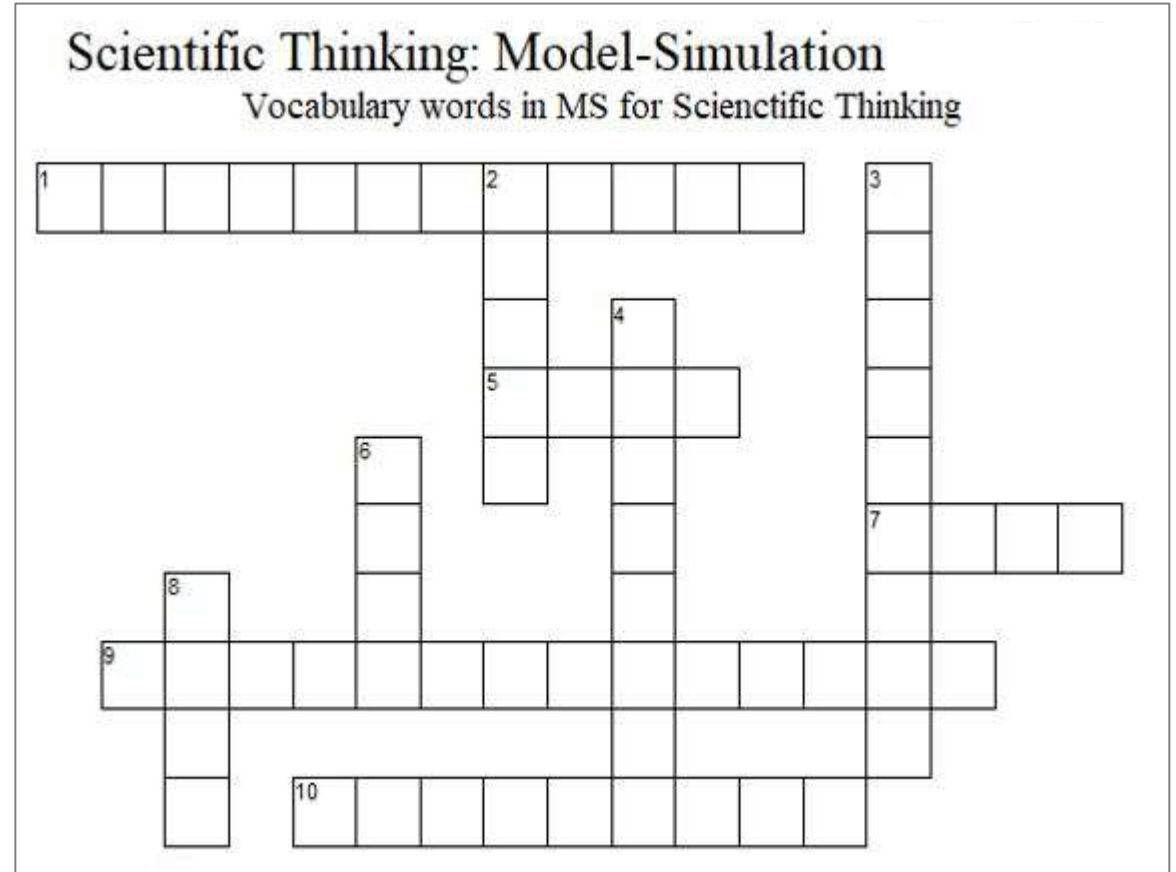
- Learning Objectives
- Introductions
 - Acknowledgements
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- CMSP
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- A crossword puzzle will appear
- Next to it will be a series of clues
- Going in order, how many can we answer?
- Load Game File.....
- **GO!**



- Feedback
- Q&A



- For more information email Carol Dwyer at cdwyer@ndia.org